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Diehr et al.

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(54) **ROBOTIC PAYLOAD TRANSPORT SYSTEM**

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***B65G 41/00*** (2006.01)
***B65G 13/07*** (2006.01)
***B65G 13/04*** (2006.01)

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CPC ........... ***B65G 41/008*** (2013.01); ***B65G 13/04*** (2013.01); ***B65G 13/07*** (2013.01); ***B65G 41/003*** (2013.01); *B65G 2205/04* (2013.01)

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,348,140 A * 9/1994 Clos .......................... B65G 13/07 198/780
5,632,371 A * 5/1997 Best .......................... B65G 13/07 193/35 TE
8,381,901 B2 * 2/2013 Yamamoto ............. B65G 23/08 198/789
9,637,318 B2 * 5/2017 Messina ................. B65G 15/00
2008/0118337 A1 * 5/2008 Vestergaard ......... B65G 41/008 414/340

(Continued)

FOREIGN PATENT DOCUMENTS

CN 108945950 A * 12/2018
CN 110217723 A * 9/2019

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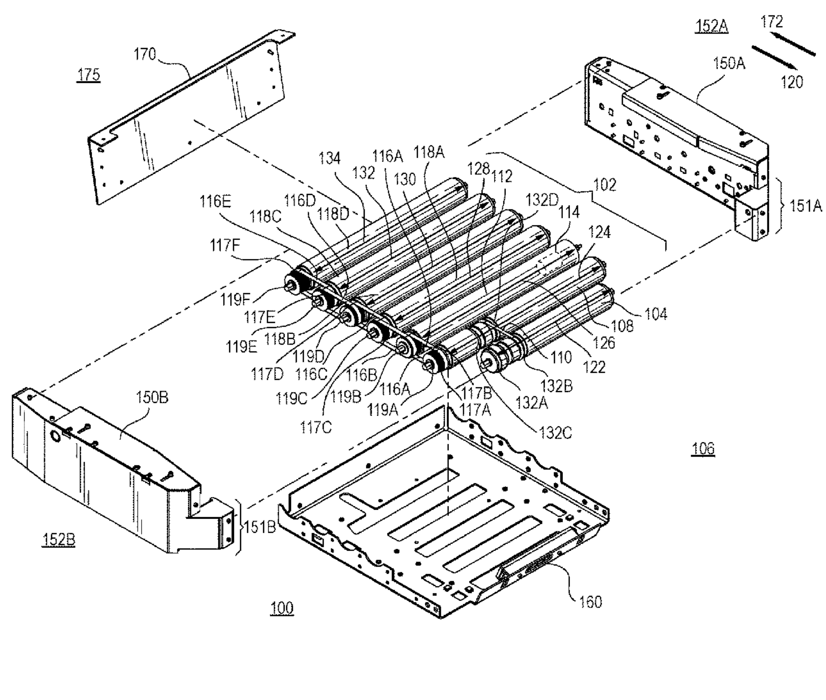
(57) **ABSTRACT**

A roller conveyor system configured for installation on top of a mobile robot to provide robotic transport of a payload includes: a roller conveyor, the roller conveyor comprising: a roller assembly, the roller assembly comprising a plurality of rollers, the rollers configured to move a payload, each of the rollers being configured to rotate, the roller assembly comprising a motorized roller and one or more auxiliary rollers, the motorized roller comprising a motor configured to cause the motorized roller to rotate; and a hybrid power transmission configured to drive the rollers, the hybrid power transmission coupling the motorized roller to at least one of the one or more auxiliary rollers, the hybrid power transmission using at least two power transmission methods.

**38 Claims, 13 Drawing Sheets**

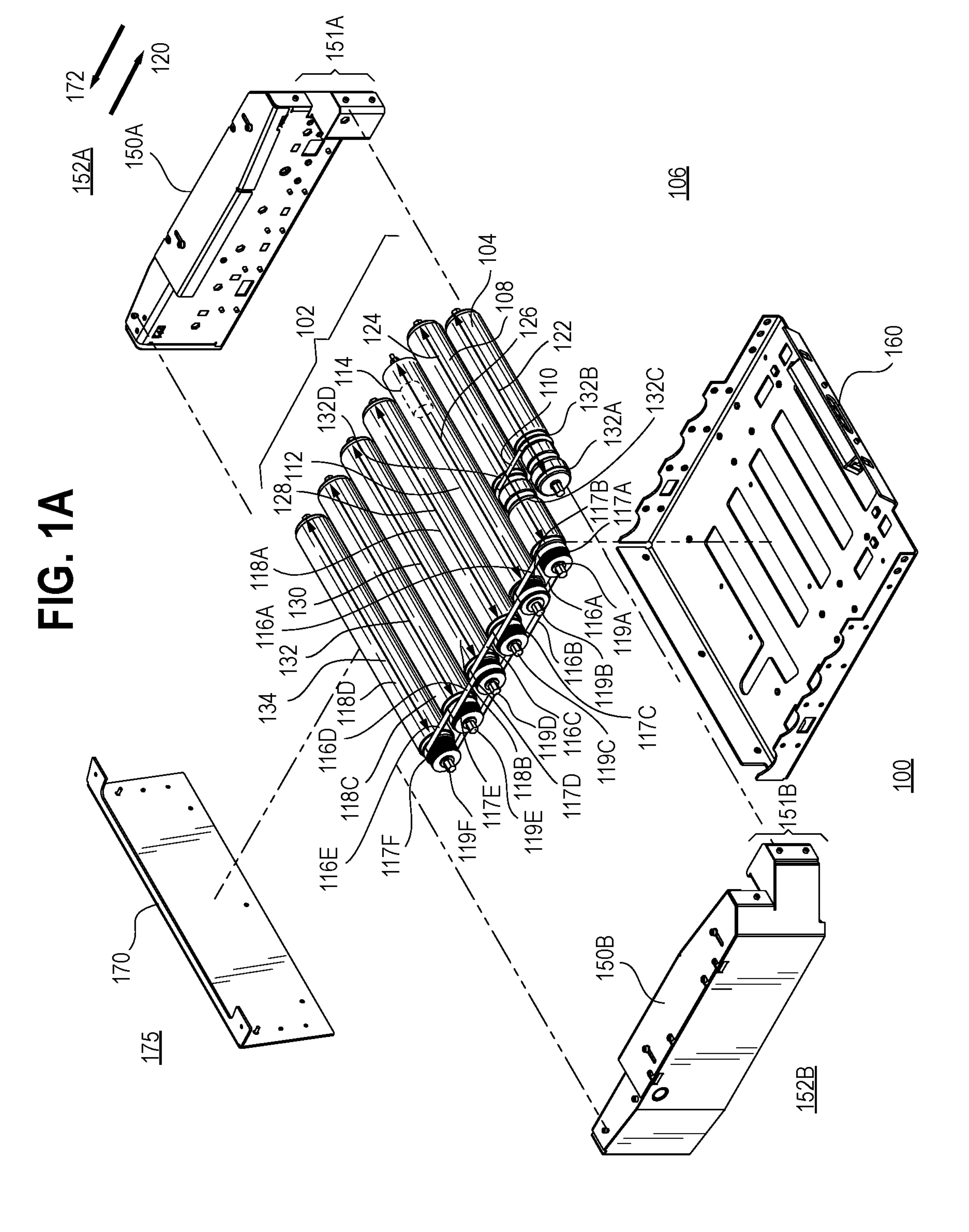


(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 2017/0334649 | A1* | 11/2017 | Ramezani | H02K 7/1016 |
| 2018/0072212 | A1* | 3/2018 | Alfaro | G05D 1/0278 |
| 2018/0237226 | A1* | 8/2018 | Kacel | B65G 13/06 |
| 2019/0291956 | A1* | 9/2019 | Pajevic | G05D 1/0088 |
| 2020/0385217 | A1* | 12/2020 | Biro | B65G 41/008 |

* cited by examiner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116B
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119B
134
118D
119D
116C
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117C
116D
118C
118B
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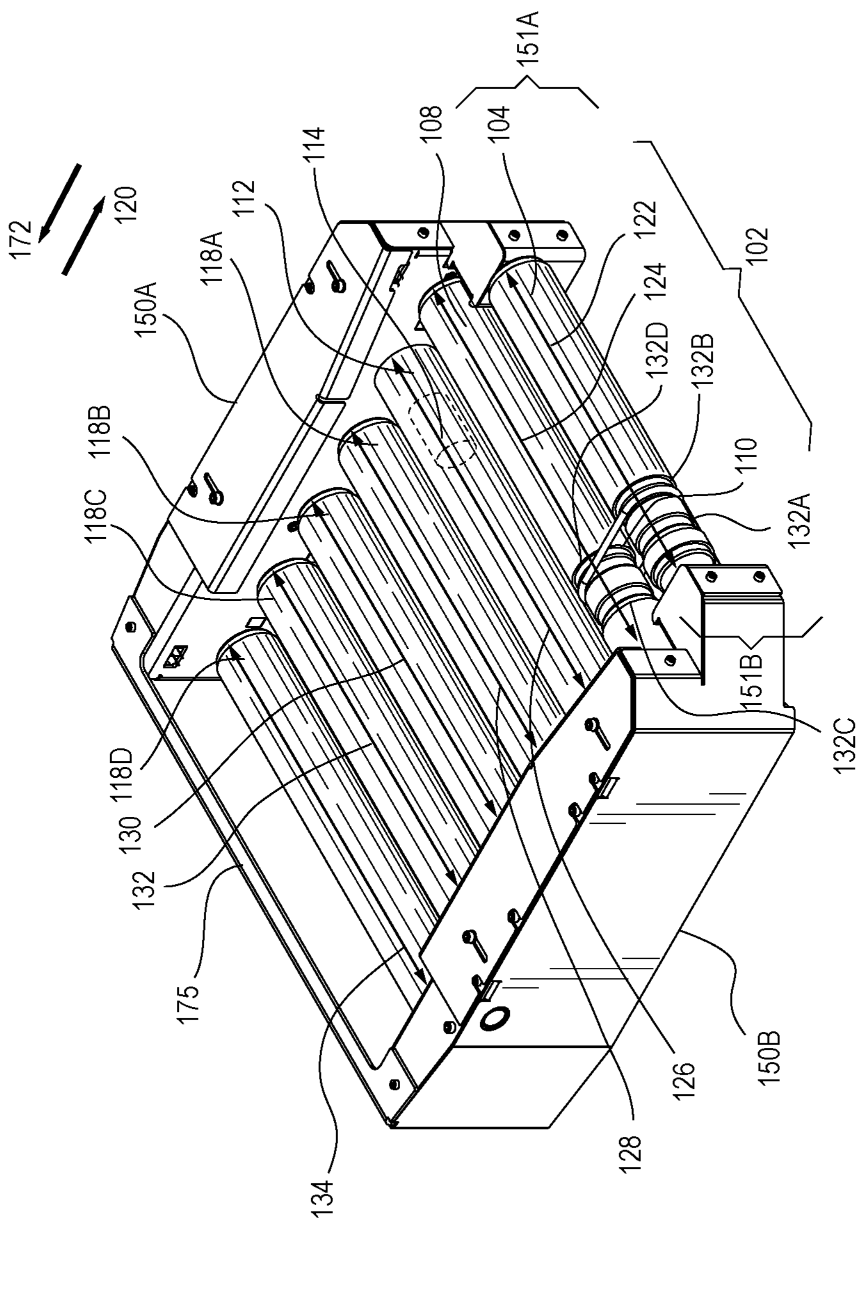
151B
150B
152B

FIG. 1A

FIG. 1B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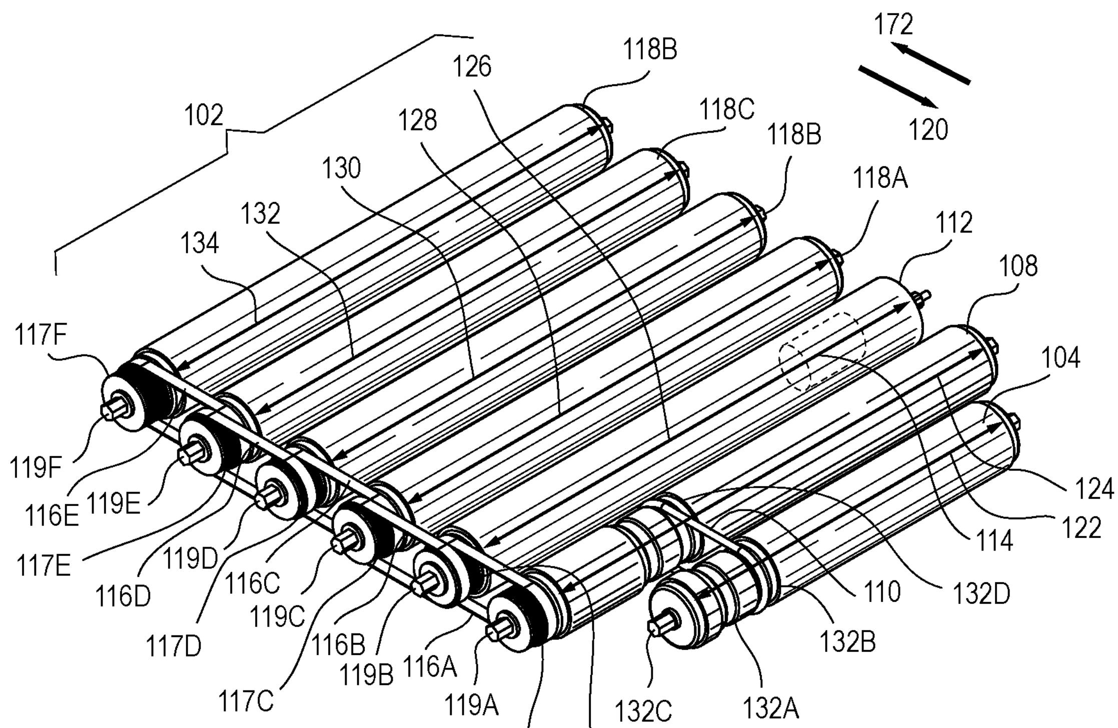
150B

FIG. 1C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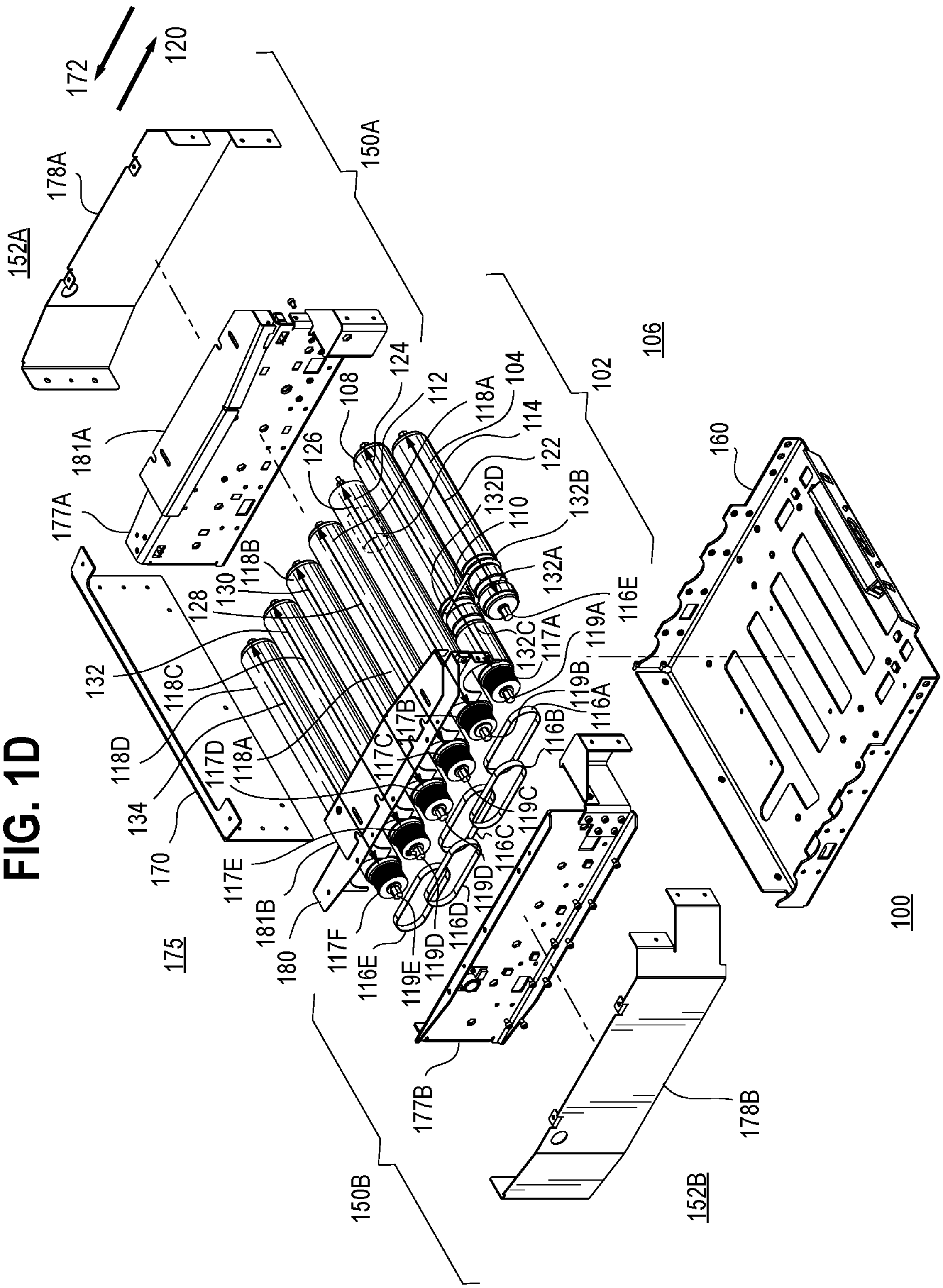
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132C
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116E
118C
118D
117D
118A
117B
117C
119B
116A
116B
119C
116C
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170
117E
181B
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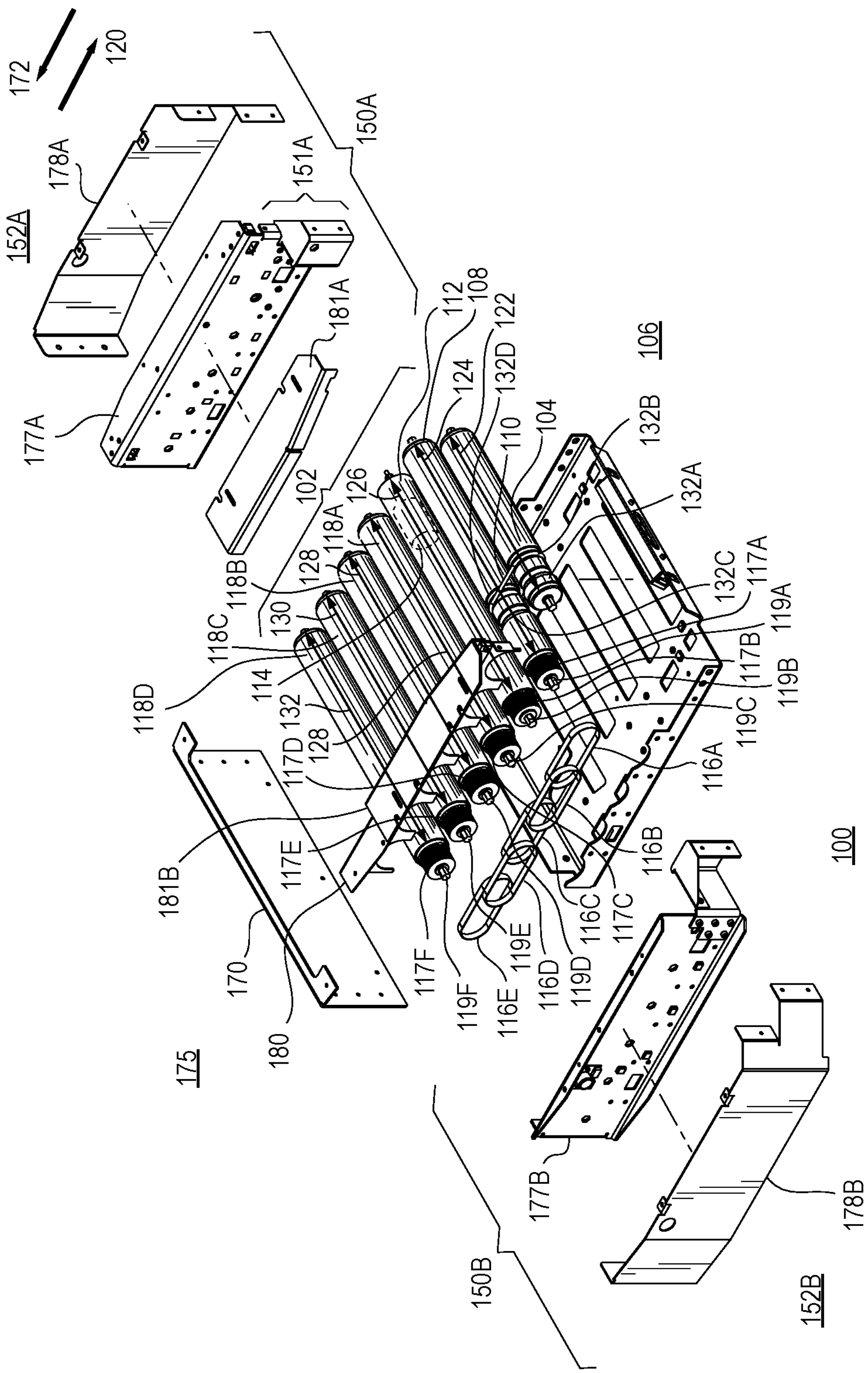
152B
100

FIG. 1D

FIG. 1E



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118C
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116A
181B
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116B
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FIG. 1F

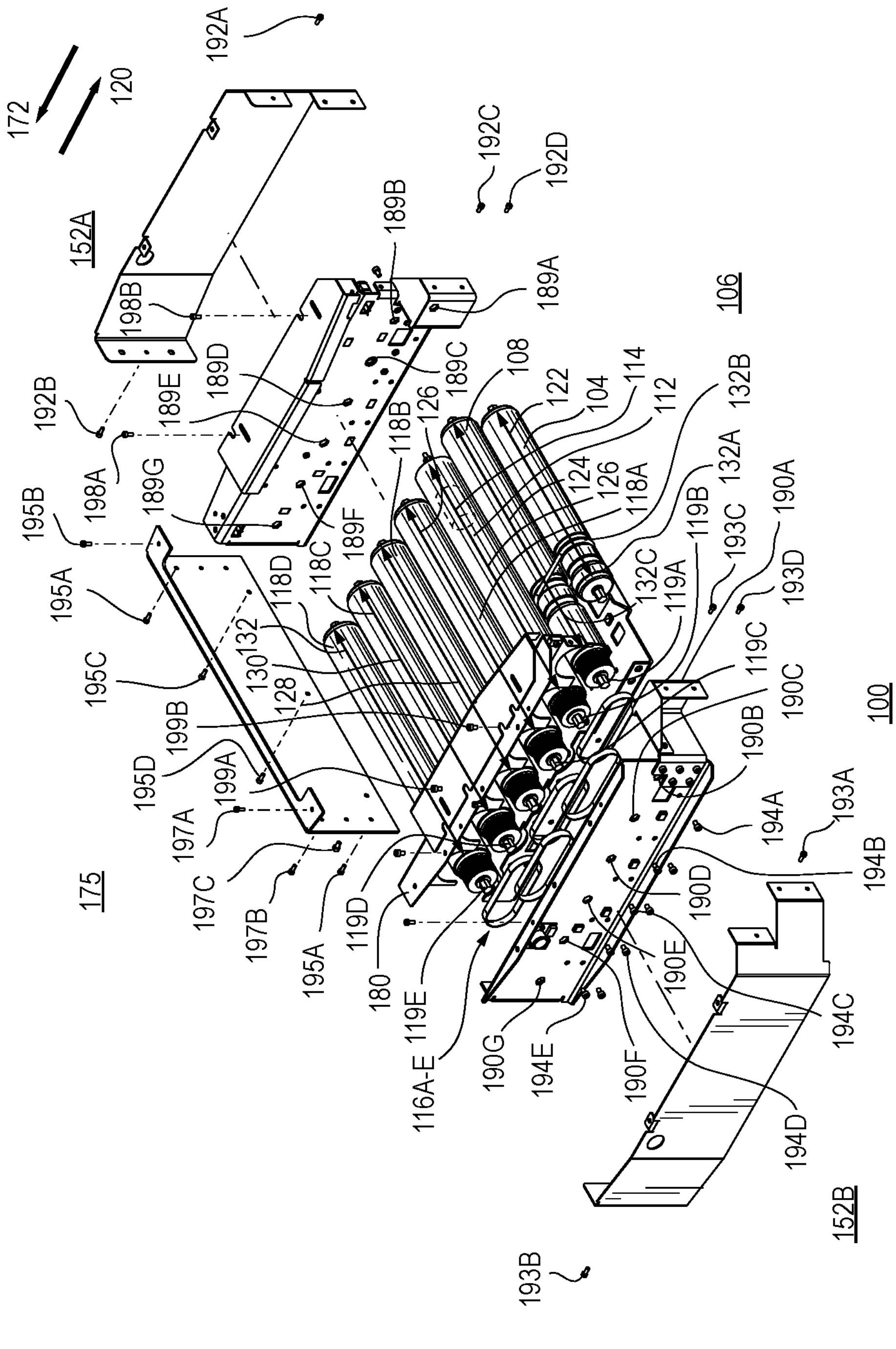
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FIG. 2A

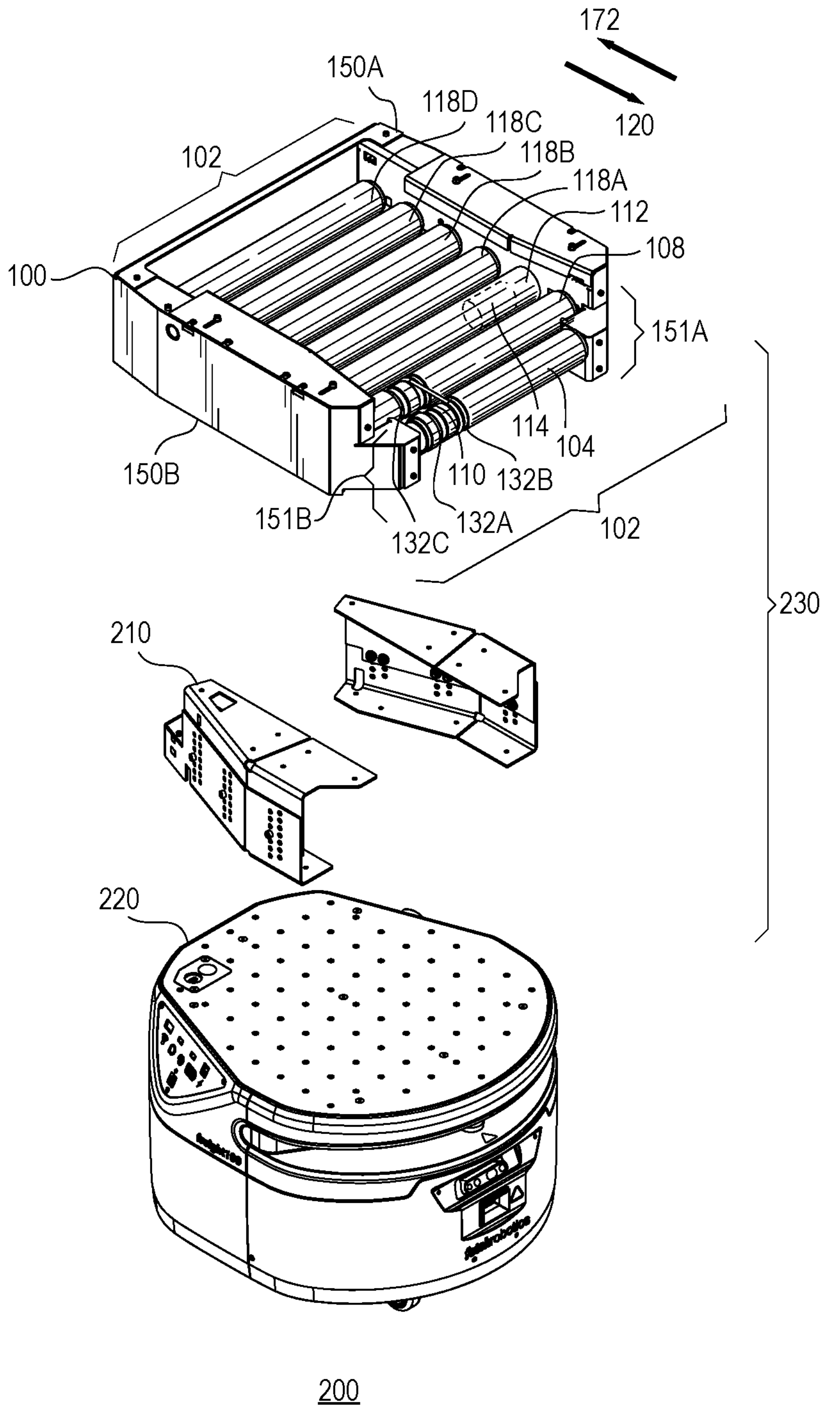
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FIG. 2B

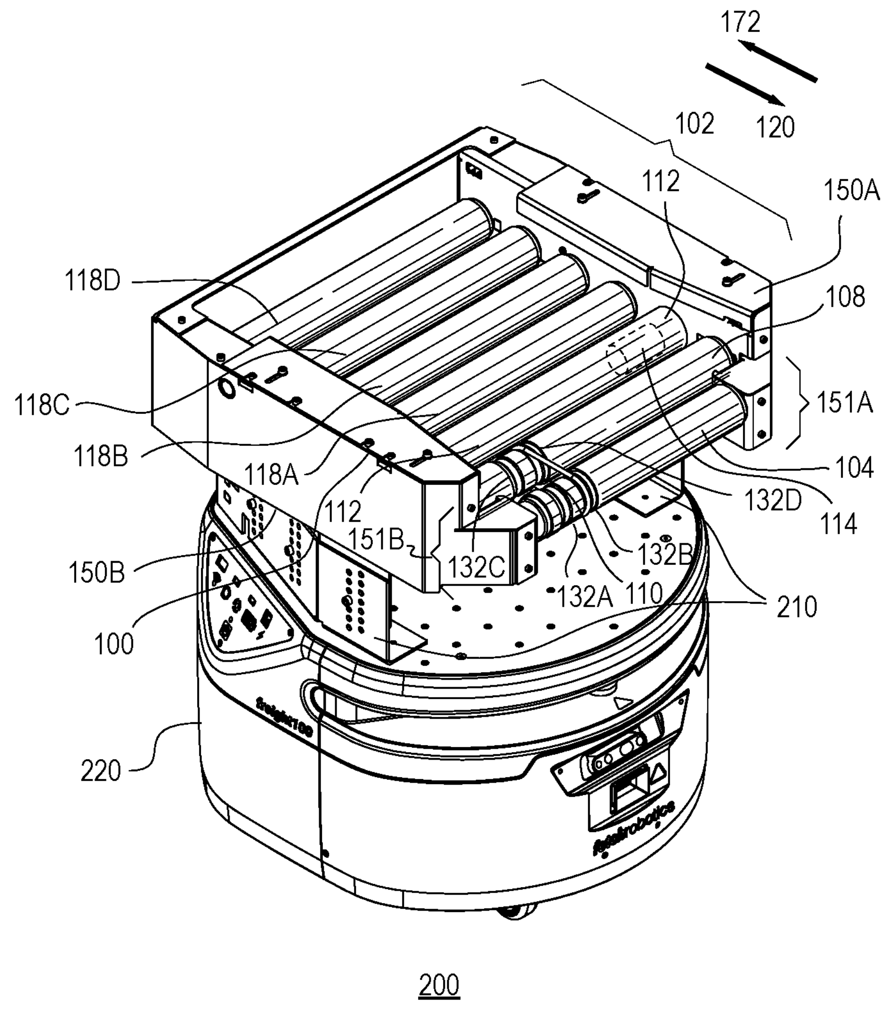
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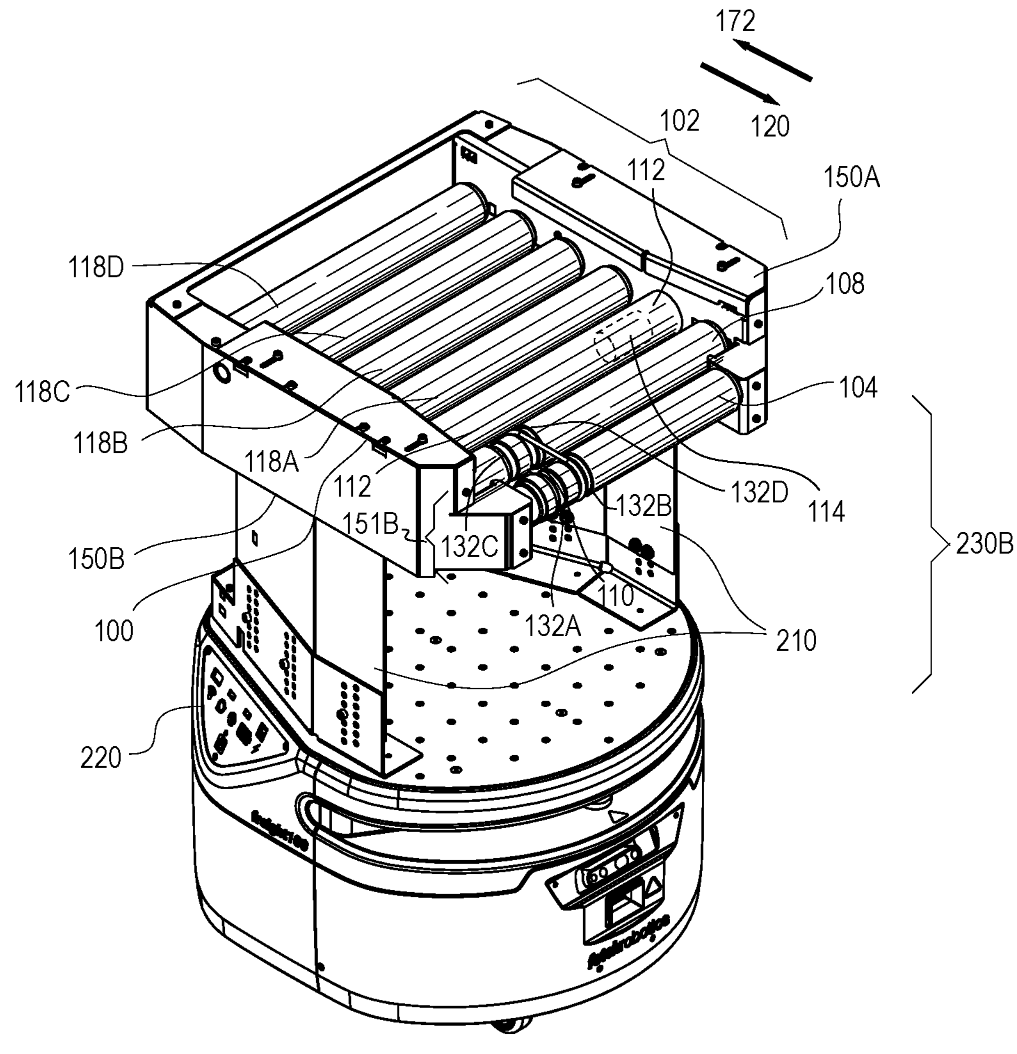
FIG. 2C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200

FIG. 2E

200

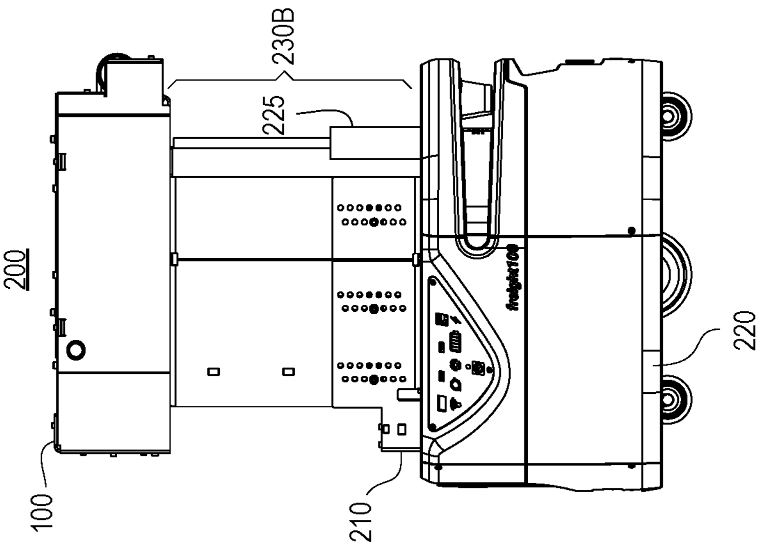


FIG. 2D

200

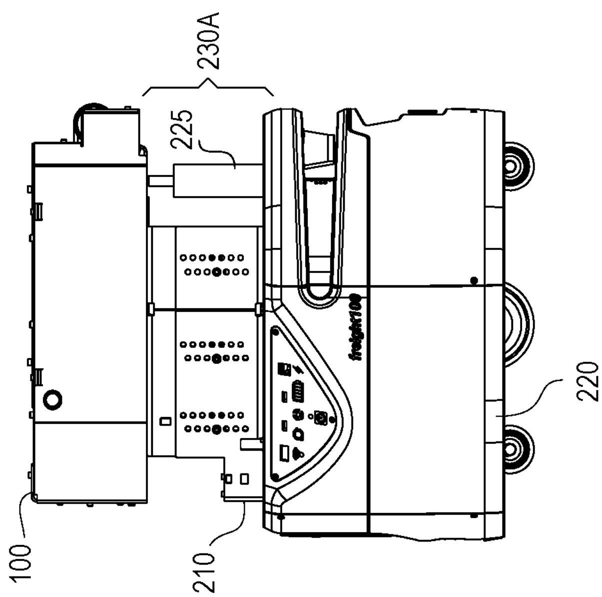

FIG. 3

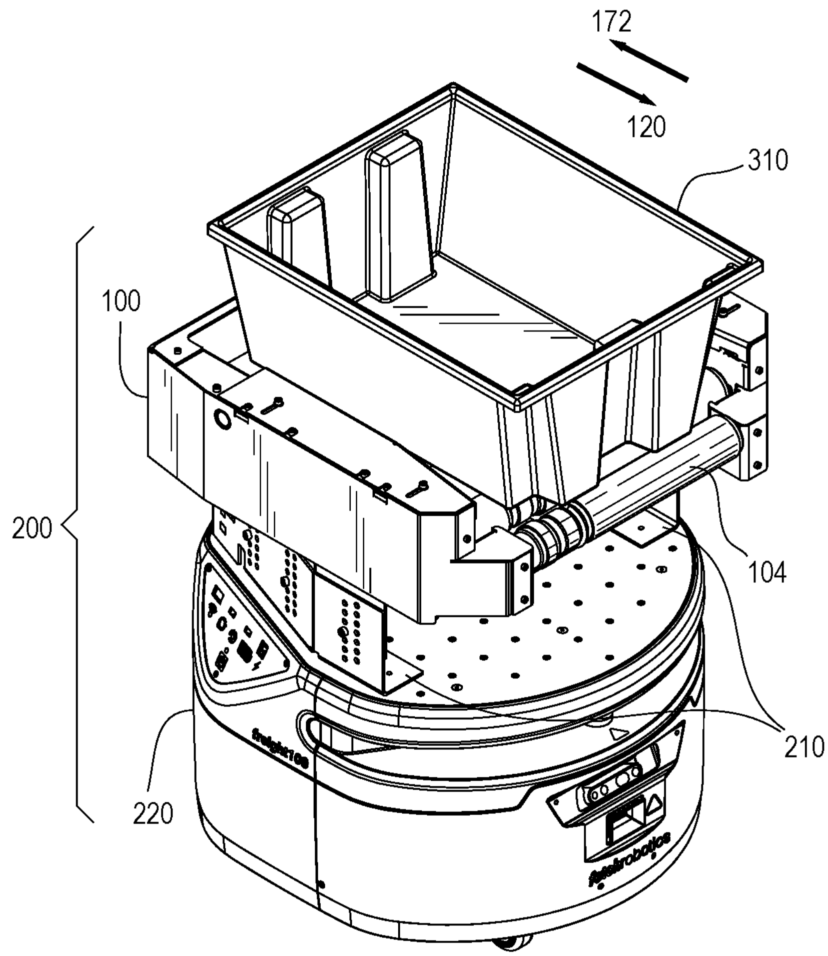

FIG. 4

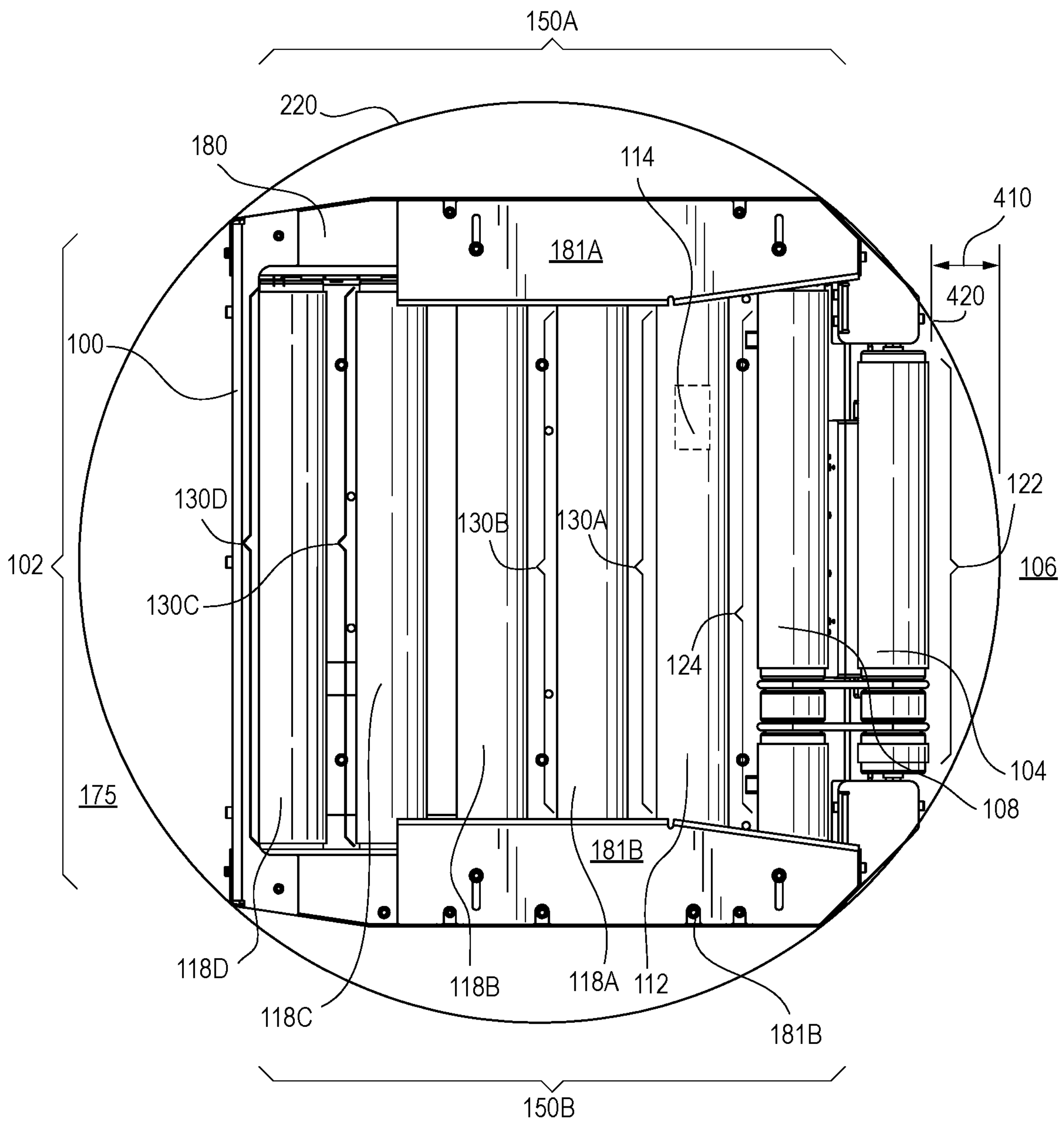
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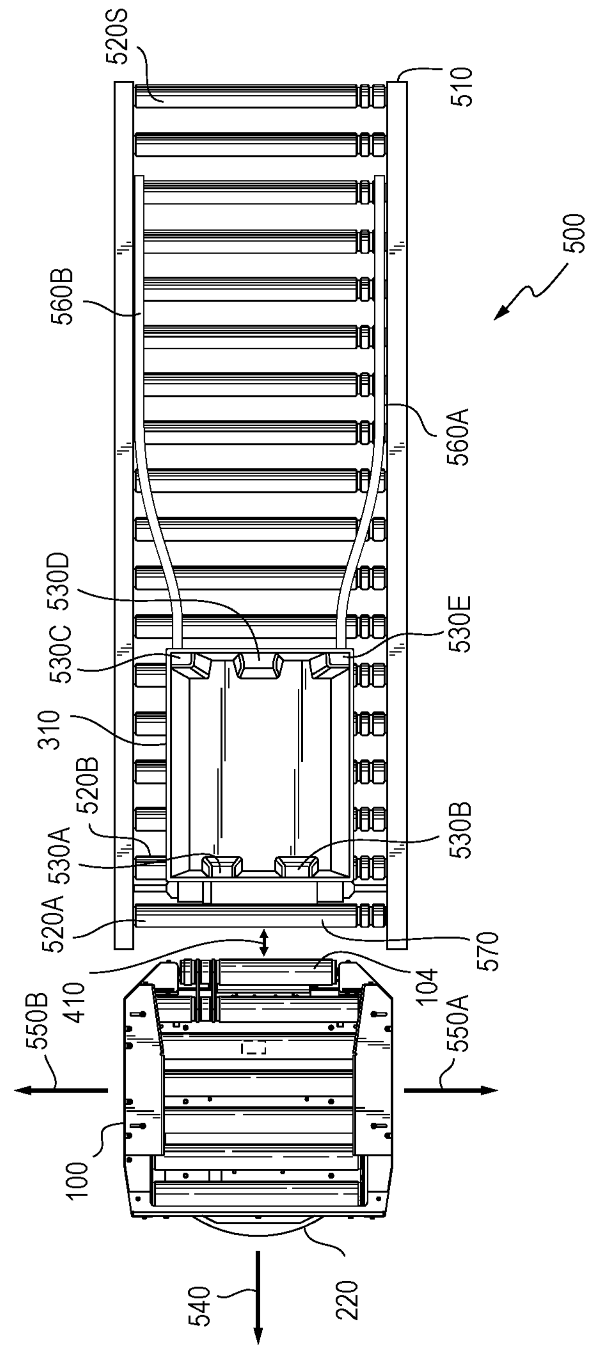
FIG. 5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# ROBOTIC PAYLOAD TRANSPORT SYSTEM

## PRIORITY CLAIM

The present application claims the priority benefit of U.S. provisional patent application No. 62/817,437 filed Mar. 12, 2019 and entitled "Hybrid Belt Transmission for Conveyor for Transport of a Mobile Robot," the disclosure of which is incorporated herein by reference.

## SUMMARY

Embodiments of the invention relate in general to the transport of a payload by Autonomous Mobile Robots (AMRs) using a roller conveyor. More specifically, embodiments of the invention relate to the transport of the payload by a robot. More specifically, embodiments of the invention relate to a conveyor for transport of the payload by the robot. More specifically, embodiments of the invention relate to a hybrid power transmission for a conveyor for transport of the payload by the robot. Still more specifically, embodiments of the invention relate to the hybrid power transmission for the conveyor for transport of the payload by a mobile robot.

A roller conveyor system configured for installation on top of a mobile robot to provide robotic transport of a payload includes: a roller conveyor, the roller conveyor comprising: a roller assembly, the roller assembly comprising a plurality of rollers, the rollers configured to move a payload, each of the rollers being configured to rotate, the roller assembly comprising a motorized roller and one or more auxiliary rollers, the motorized roller comprising a motor configured to cause the motorized roller to rotate; and a hybrid power transmission configured to drive the rollers, the hybrid power transmission coupling the motorized roller to at least one of the one or more auxiliary rollers, the hybrid power transmission using at least two power transmission methods.

A roller conveyor system configured for installation on top of a mobile robot to provide robotic transport of a payload includes: a roller conveyor, the roller conveyor comprising: a roller assembly comprising a plurality of rollers, the rollers configured to move a payload, each of the rollers being configured to rotate, the roller assembly comprising a leading roller positioned nearest to a front side of the roller conveyor, the leading roller having a leading roller length, the roller assembly further comprising a motorized roller, the motorized roller comprising a motor configured to cause the motorized roller to rotate, the motorized roller having a motorized roller length; and a drive configured to drive the rollers, the drive coupling the motorized roller to the leading roller, wherein the leading roller length is less than one or more of the secondary roller length, the motorized roller length, and the respective auxiliary roller lengths.

A roller conveyor system configured for installation on top of a mobile robot to provide robotic transport of a payload, includes: a roller conveyor, the roller conveyor comprising: a roller assembly comprising a plurality of rollers rotating in a same direction, the rollers configured to move a payload toward a front side of the roller conveyor, each of the rollers being configured to rotate, the roller assembly comprising a leading roller positioned nearest to a front side of the roller conveyor, the leading roller having a leading roller length, the roller assembly further comprising a motorized roller, the motorized roller comprising a motor configured to cause the motorized roller to rotate, the motorized roller having a motorized roller length, the roller assembly further comprising one or more auxiliary rollers, the auxiliary rollers being adjacent to and behind the motorized roller, each of the auxiliary rollers having a respective auxiliary roller length, the motorized roller being physically coupled to the one or more auxiliary rollers by one or more poly-V belts, the roller assembly further comprising a secondary roller physically coupled to the motorized roller by a poly-V belt, the secondary roller also physically coupled to the leading roller by an O-ring belt, the secondary roller positioned adjacent to and immediately behind the leading roller, the secondary roller having a secondary roller length, wherein the motorized roller is positioned adjacent to and immediately behind the secondary roller, wherein the leading roller length is less than the secondary roller length, the leading roller length is less than the motorized roller length, and the leading roller length is less than each of the respective auxiliary roller lengths; a backstop operably connected to the roller assembly at a back side of the conveyor, the backstop configured to stop motion of the payload toward the back side of the conveyor; and a hybrid belt drive configured to drive the rollers, the drive coupling the motorized roller to the leading roller; and a riser assembly configured to support the roller conveyor, the riser assembly comprising an actuator usable to adjust a height of the roller conveyor above the mobile robot.

## DESCRIPTION OF THE DRAWINGS

The accompanying drawings provide visual representations which will be used to more fully describe various representative embodiments and can be used by those skilled in the art to better understand the representative embodiments disclosed herein and their inherent advantages. In these drawings, like reference numerals identify corresponding elements.

FIGS. **1**A-**1**F are a set of six drawings of a robotic payload conveyor depicting components and subassemblies of the conveyor.

FIGS. **2**A-**2**E are a set of five drawings of the robotic payload transport system.

FIG. **3** depicts a fully assembled view of the principal components of the robotic payload transport system while in use to transport a payload.

FIG. **4** is a top view drawing of the roller conveyor mounted to the mobile robot.

FIG. **5** is a top view drawing of a system comprising the roller conveyor mounted on the mobile robot in use in conjunction with a stationary conveyor.

## DETAILED DESCRIPTION

This invention relates to a system for transport of a payload by mobile robots in an industrial setting, and entails industrial control and automation, industrial safety, and industrial conveyor systems.

A robotic payload transport system comprises a robotic payload roller conveyor.

The system comprises a plurality of rollers. For example, the system comprises a leading roller positioned near a front side of the roller conveyor, a secondary roller positioned adjacent to and immediately behind the leading roller, a motorized roller, and a plurality of auxiliary rollers. For example, the plurality of auxiliary rollers are positioned closer to a back side of the roller conveyor than the motorized roller. For example, the system comprises four auxiliary rollers. A motorized roller comprises a built-in gear motor. According to certain embodiments, the motorized roller is coupled to other rollers via a hybrid power transmission that uses a combination of power transmission methods to enable the mechanism to manipulate payloads when mounted on a mobile robot.

The gear motor causes the motorized roller to rotate. Since the motorized roller is linked to the other rollers via the hybrid power transmission, all the rollers rotate, thereby rolling the payload either onto the robot in a loading operation or rolling the payload off of the robot in an unloading operation. For example, a leading roller is coupled to a secondary roller using an O-ring belt. An O-ring belt comprises a round belt. The O-ring belt can be stretched so that a belt tensioner is not required. The O-ring belts are configured to be held in an O-ring groove on the roller. The O-ring groove is configured to accommodate the O-ring belt. The O-ring groove is further configured to prevent the O-ring belt from moving from side to side on the roller. The secondary roller is coupled to the motorized roller using a poly-V belt.

For example, five poly-V belts couple the four auxiliary rollers, the motorized roller, and the secondary roller. The poly-V belt comprises a power transmission belt. The poly-V belt comprises a plurality of longitudinal ribs. The poly-V belt connects two adjacent rollers, for example, a secondary roller and a first auxiliary roller, or the first auxiliary roller and a second auxiliary roller, via poly-V hubs comprised in the two adjacent rollers. Alternatively, or additionally, the poly-V belt connects rollers that are not adjacent. For example, the poly-V hub comprises a plurality of concentric grooves. For example, the poly-V hub comprises approximately ten concentric grooves. The poly-V hub is configured to transmit power between adjacent rollers that are coupled by the poly-V belt. The poly-V belt transmits torque by contact between one or more of the ribs comprised in the poly-V belt and one or more of the grooves comprised in the poly-V hub. The motorized roller is coupled, either directly or indirectly, to one or more auxiliary rollers using one or more poly-V belts. To achieve this, the secondary roller uses both an O-ring groove and a poly-V hub to link both of these separate power transmission systems into one.

A key innovation is the unprecedented design of the secondary roller, which in certain embodiments, as mentioned, comprises both the poly-V hub for mating with the poly-V belts as well as the O-ring grooves to interface with O-ring belts. The poly-V belts and O-ring belts ensure that when the motorized roller rotates, rotational power is transmitted to the four auxiliary rollers, the secondary roller, and leading roller. Accordingly, when moving a payload, all rollers rotate substantially together in substantially the same direction.

The exact configuration of the O-ring belts and the poly-V belts can vary in a number of different configurations while remaining within the confines of the invention. In certain configurations, it may be possible to use zero poly-V belts. In certain configurations, it may be possible to use zero O-ring belts. Moreover, many other methods of power transmission can also be used in addition to or as alternatives to one or more of O-ring belts and poly-V belts. Alternative methods of power transmission usable by embodiments of the invention include, in addition to one or more of O-ring belts and poly-V belts, roller chains, timing belts, round belts, V-belts, flat belts, line shafts, and gears.

FIGS. **1**A-**1**F are a set of six drawings of a robotic payload conveyor depicting components and subassemblies of the conveyor.

FIG. **1**A depicts an exploded view of principal components of a robotic payload conveyor **100**. The conveyor **100** comprises a conveyor belt roller assembly **102**.

The roller assembly **102** comprises a leading roller **104** that is configured to rotate and is, as its name suggests, is positioned nearest to a front side **106** of the conveyor **100**, that is, as the roller **104** that is closest to the front side **106**. As such, the leading roller **104** comprises the roller **104** that is a first contact when a payload (not shown in this figure) is unloaded off of a robot (not shown in this figure) onto the conveyor **100**. Alternatively, or additionally, the leading roller **104** comprises the roller **104** that is a last contact when a payload (not shown in this figure) is loaded onto the robot (not shown in this figure) off the conveyor **100**.

The roller assembly **102** further comprises a secondary roller **108** that is configured to rotate and is positioned adjacent to and immediately behind the leading roller **104**. The secondary roller **108** is coupled, either directly or indirectly, to the leading roller **104**. For example, and as depicted, the secondary roller is physically coupled to the leading roller **104**. For example, and as depicted, the secondary roller **108** is coupled to the leading roller **104** by an O-ring belt **110**.

The roller assembly **102** further comprises a motorized roller **112** that is configured to rotate and is positioned adjacent to and immediately behind the secondary roller **108**. The motorized roller **112** comprises a motor **114**, the motor configured to cause the motorized roller **112** to rotate and thereby to cause any other rollers **104**, **108** coupled to the motorized roller **112** to also rotate. For example, the motor **114** comprises a gear motor **114**. The motorized roller **112** is coupled to the secondary roller **108** by a first poly-V belt **116**A.

The first poly-V belt **116**A comprises a power transmission belt **116**A. The first poly-V belt **116**A comprises a plurality of longitudinal ribs (not shown). The secondary roller **108** comprises a secondary poly-V hub **117**A. The motorized roller **112** comprises a motorized poly-V hub **117**A. The first poly-V belt **116**A connects two adjacent rollers, the secondary roller **108** and the motorized roller **112**, via poly-V hubs comprised in the two adjacent rollers, namely, via a secondary poly-V hub **117**A and a motorized poly-V hub **117**B. Alternatively, or additionally, the first poly-V belt **116**A connects rollers that are not adjacent.

The secondary roller **108** comprises the secondary poly-V hub **117**A. The motorized roller **112** further comprises the motorized poly-V hub **117**B. For example, the secondary poly-V hub **117**A comprises approximately ten concentric grooves (not shown). For example, the motorized poly-V hub **117**B comprises approximately ten concentric grooves (not shown). The first poly-V belt **116**A connects the two adjacent rollers, the secondary roller **108** and the motorized roller **112**, via the secondary poly-V hub **117**A comprised in the secondary roller **108** and the motorized poly-V hub **117**B comprised in the motorized roller **112**.

Like all the poly-V hubs **117**A-**117**F, the secondary poly-V hub **117**A and the motorized poly-V hub **117**A are configured to transmit power between adjacent rollers. In the case of the secondary poly-V hub **117**A and the motorized poly-V hub **117**B, power is transmitted between the secondary roller **108** and the motorized roller **112**, the secondary roller **108** and the motorized roller **112** being coupled by the first poly-V belt **116**A. The first poly-V belt **116**A transmits torque by contact between one or more of the ribs (not shown) comprised in the first poly-V belt **116**A and one or more of the grooves (not shown) comprised in the secondary poly-V hub **117**A.

The roller assembly **102** further comprises a plurality of auxiliary rollers **118**A, **118**B, **118**C, **118**D, each of the auxiliary rollers **118**A-**118**D being configured to rotate, the auxiliary rollers **118**A-**118**D being positioned adjacent to and immediately behind the motorized roller **112**.

Each of the rollers **104**, **108**, **112**, **118**A-**118**D further comprises a respective shaft **119**A-**119**G on which the respective roller **104**, **108**, **112**, **118**A-**118**D rotates. For example, the shafts **119**A-**119**G each comprise a hexagonal shaft **119**A-**119**G.

Alternatively, or additionally, at least one of the shafts **119**A-**119**G is non-hexagonal. For example, at least one of the shafts **119**A-**119**G comprises a non-hexagonal shaft **119**A-**119**G. The roller assembly **102** therefore comprises a plurality of rollers **104**, **108**, **112**, **118**A-**118**D, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D preferably being configured to rotate. Alternatively, at least of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D is not configured to rotate.

For example, the leading roller **104** comprises a leading hexagonal shaft **119**A on which the leading roller **104** rotates. For example, the secondary roller **108** comprises a secondary hexagonal shaft **119**B on which it rotates. For example, the motorized roller **112** comprises a motorized hexagonal shaft **119**C on which it rotates. For example, each of the four auxiliary rollers **118**A-**118**D comprises a respective first, second, third, or fourth auxiliary hexagonal shaft **119**D-**119**G on which it rotates. Preferably, but not necessarily, the rollers **104**, **108**, **112**, **118**A-**118**D all rotate in a same direction, either all clockwise (with respect to a selected reference point) or all counter-clockwise (with respect to the reference point).

The plurality of rollers **104**, **108**, **112**, **118**A-**118**D collectively form the roller assembly **102** configured to move a payload (not shown in FIG. **1**A) along the conveyor **100** in a forward direction **120** toward the front side **106** of the conveyor **100**. Alternatively, or additionally, as discussed below, the roller assembly **102** is configured to move the payload (not shown in FIG. **1**A) along the conveyor **100** in a backward direction. The roller assembly **102** is depicted in more detail in FIG. **1**C.

Each of the auxiliary rollers **118**A-**118**D comprises a respective poly-V hub **117**C-**117**F. The first auxiliary roller **118**A comprises a first auxiliary poly-V hub **117**C. The second auxiliary roller **118**B comprises a second auxiliary poly-V hub **117**D. The third auxiliary roller **118**C comprises a third auxiliary poly-V hub **117**E. The fourth auxiliary roller **118**D comprises a fourth auxiliary poly-V hub **117**F.

For example, the first auxiliary poly-V hub **117**C comprises approximately ten concentric grooves (not shown). For example, the second auxiliary poly-V hub **117**D comprises approximately ten concentric grooves (not shown). For example, the third auxiliary poly-V hub **117**E comprises approximately ten concentric grooves (not shown). For example, the fourth auxiliary poly-V hub **117**F comprises approximately ten concentric grooves (not shown). The first poly-V belt **116**A connects the two adjacent rollers, the secondary roller **108** and the motorized roller **112**, via the secondary poly-V hub **117**A comprised in the secondary roller **108** and the motorized poly-V hub **117**B comprised in the motorized roller **112**.

The leading roller **104** has a leading roller length **122**. The secondary roller **108** has a secondary roller length **124**. The motorized roller **112** has a motorized roller length **126**. The auxiliary rollers **118**A-**118**D have respective auxiliary roller lengths **130**A-**130**D. For example, the leading roller length **122** is less than the motorized roller length **126**. For example, the leading roller length **122** is less than one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D. As depicted, the leading roller length **122** is less than the secondary roller length **124**, the leading roller length **122** is less than the motorized roller length **126**, and the leading roller length **122** is less than each of the respective auxiliary roller lengths **130**A-**130**D.

The small leading roller length **122** is helpful because it allows the robot (not shown in this figure) carrying the conveyor **100** to approach a payload transfer point more closely than it would otherwise be able to do. When executing a transfer of the payload (not shown in this figure) between the conveyor **100** and another device (not shown in this figure), which in practical terms means a transfer of the payload (not shown in this figure) between the leading roller **104** and another device (not shown in this figure), the closer the leading roller **104** is to the other device (not shown in this figure), the smoother and more reliable the transfer will be. This feature is shown in detail in FIG. **4** below.

The leading roller **104** comprises a first leading O-ring groove **132**A, the first leading O-ring groove **132**A configured to accommodate an O-ring belt (this O-ring belt is not shown in this figure). The leading roller **104** further comprises a second leading O-ring groove **132**B, the second leading O-ring groove **132**B configured to accommodate the O-ring belt **110**. Although as depicted, the first leading O-ring groove does not comprise an O-ring belt, alternative embodiments use two O-ring belts in order to transmit increased power between the leading roller **104** and the secondary roller **108**. The O-ring belt **110** comprises a generally round belt **110**. Preferably, but not necessarily, the O-ring belt **110** comprises an elastic material, for example, polyurethane. Preferably, but not necessarily, the O-ring belt **110** can be stretched so that a belt tensioner is not required. The second leading O-ring groove **132**B is further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**. Preferably, but not necessarily, the O-ring belt **110** is configured to be held on the primary roller **104** by the second leading O-ring groove **132**B.

The secondary roller **108** comprises a first secondary O-ring groove **132**C, the first secondary O-ring groove **132**C configured to accommodate an O-ring belt (this O-ring belt is not shown in this figure). The first secondary O-ring groove **132**C is further configured to prevent the O-ring belt **110** from moving from side to side on the secondary roller **108**. The secondary roller **108** further comprises a second secondary O-ring groove **132**D, the second secondary O-ring groove **132**B configured to accommodate the O-ring belt **110**.

The O-ring belt **110** is attached to the secondary roller **108** using the second secondary O-ring groove **132**D. The secondary roller **108** is coupled to the motorized roller **112** using the first poly-V belt **116**A. The secondary roller **108** thereby is configured to receive mechanical power from the motorized roller **112** via the first poly-V belt **116**A. The secondary roller **108** thereby is further configured to transmit mechanical power to the leading roller **104** via the O-ring belt **110**.

The motorized roller **112** is coupled, either directly or indirectly, to one or more auxiliary rollers **118**A-**118**D. For example, and as depicted, the secondary roller **112** is physically coupled to the first auxiliary roller **118**A. For example, and as depicted, the secondary roller **108** is physically coupled to the leading roller **104** by an O-ring belt **110**.

As depicted, the motorized roller **112** is physically coupled to the auxiliary rollers **118**A-**118**D by one or more poly-V belts, in this case, by four poly-V belts **116**B-**116**E.

The second poly-V belt **116**B comprises a power transmission belt **116**B. The second poly-V belt **116**B comprises a plurality of longitudinal ribs (not shown). The second poly-V belt **116**B connects two adjacent rollers, the motorized roller **112** and the first auxiliary roller **118**A, via poly-V hubs comprised in the two adjacent rollers, namely, via the motorized poly-V hub **117**B and the first auxiliary poly-V hub **117**C. Alternatively, or additionally, the second poly-V belt **116**B connects rollers that are not adjacent.

The secondary roller **108** again comprises the secondary poly-V hub **117**A. The motorized roller **112** comprises a motorized poly-V hub **117**B. For example, the secondary poly-V hub **117**A comprises approximately ten concentric grooves (not shown). For example, the motorized poly-V hub **117**B comprises approximately ten concentric grooves (not shown). The third poly-V belt **116**C connects the two adjacent rollers, the first auxiliary roller **118**A and the second auxiliary roller **118**B, via the first auxiliary poly-V hub **117**C comprised in the first auxiliary roller **118**A and the second auxiliary poly-V hub **117**D comprised in the second auxiliary roller **118**B.

Like all the poly-V hubs **117**A-**117**F, the first auxiliary poly-V hub **117**C and the second auxiliary poly-V hub **117**D are configured to transmit power between adjacent rollers. In the case of the secondary poly-V hub **117**A and the motorized poly-V hub **117**B, power is transmitted between the secondary roller **108** and the motorized roller **112**, the secondary roller **108** and the motorized roller **112** being coupled by the first poly-V belt **116**A. The first poly-V belt **116**A transmits torque by contact between one or more of the ribs (not shown) comprised in the first poly-V belt **116**A and one or more of the grooves (not shown) comprised in the secondary poly-V hub **117**A.

A parallel description describes the fourth poly-V belt **116**D, which connects the second auxiliary roller **118**B and the third auxiliary roller **118**C. A parallel description also described the fifth poly-V belt **116**E, which connects the third auxiliary roller **118**C and the fourth auxiliary roller **118**D.

The robotic payload conveyor **100** further comprises a left side assembly **150**A and a right side assembly **150**B. The left side assembly **150**A is located on a left side **152**A of the conveyor **100**, and the right side assembly **150**B is located on a right side **152**B of the conveyor **100**.

The roller assembly **102** is operably connected to the left side assembly **150**A. The roller assembly is operably connected to the right side assembly **150**B. More specifically, at least one of the left side assembly **150**A and the right side assembly **150**B hold in place at least one of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D while allowing at least one of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D to rotate. Preferably, but not necessarily, both the left side assembly **150**A and the right side assembly **150**B hold in place at least one of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D while allowing at least one of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D to rotate. Most preferably, but not necessarily, and as depicted, both the left side assembly **150**A and the right side assembly **150**B hold in place each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D while allowing each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D to rotate. As depicted, the left side assembly **150**A comprises a left side assembly bulb **151**A and the right side assembly **150**B comprises a right side assembly bulb **151**B, the left side assembly bulb **151**A and the right side assembly bulb **151**B together configured to hold the leading roller **104** in place so that the leading roller length **122** is less than one or more of one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D. As depicted, the left side assembly bulb **151**A extends toward a center of the conveyor **100** so as to shorten the leading roller length **122** relative to the other roller lengths **124**, **126**, **130**A-**130**D. As depicted, the right side assembly bulb **151**B extends toward a center of the conveyor **100** so as to shorten the leading roller length **122** relative to the other roller lengths **124**, **126**, **130**A-**130**D.

Each of the respective hexagonal shafts **119**A-**119**G is held in place by one or more of the left side assembly **150**A and by the right side assembly **150**B. (More details are provided in FIG. **1**F.) Preferably, but not necessarily, each of the respective hexagonal shafts **119**A-**119**G is held in place by both the left side assembly **150**A and the right side assembly **150**B. Preferably, but not necessarily, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D rotates about the respective hexagonal shaft **119**A-**119**G. Alternatively, or additionally, one or more of the respective hexagonal shafts **119**A-**119**G is free to rotate while being held in place by the left side assembly **150**A and by the right side assembly **150**B.

The conveyor **100** further comprises a base assembly **160**. The base assembly **160** serves as a main structural member of the robotic payload conveyor **100**. The base assembly **160** is operably connected to the left side assembly **150**A and to the right side assembly **150**B. The base assembly **160** supports the left side assembly **150**A and the right side assembly **150**B. The base assembly **160** is configured to support the roller assembly **102**.

The conveyor **100** further comprises an optional backstop **170**. The backstop **170** is operably connected to the left side assembly **150**A and to the right side assembly **150**B. The backstop **170** is configured to stop motion of a payload (not shown in FIG. **1**A) in a backward direction **172** toward a back side **175** of the conveyor **100**. The backstop **170** thereby allows the conveyor **100** to move the payload (not shown in FIG. **1**A) to the back side **175** of the conveyor **100** until the payload contacts the backstop **170**. Alternatively, or additionally, the roller assembly **102** is configured to move the payload (not shown in FIG. **1**A) along the conveyor **100** in a backward direction. The backstop **170** can be removed.

The rollers **104**, **108**, **112**, **118**A-**118**D are configured to move the payload (not shown in this figure) toward a front side **106** of the roller conveyor. Alternatively, or additionally, the rollers **104**, **108**, **112**, **118**A-**118**D are configured to move the payload (not shown in this figure) toward a back side of the roller conveyor.

To summarize, the base assembly **160** is fastened to, and supports, both the left side assembly **150**A and the right side assembly **150**B using fasteners, which are shown in more detail in FIG. **1**F. The backstop **170** attaches to the left side assembly **150**A and to the right side assembly **150**B. Together, these four parts—the base assembly **160**, the left side assembly **150**A, the right side assembly **150**B, and the backstop **170**—form a main structure of the conveyor **100**. The leading roller **104**, the secondary roller **108**, the motorized roller **112**, and the auxiliary rollers **118**A-**118**D are supported between the left side assembly **150**A and the right side assembly **150**B by respective hexagonal shafts of each roller **104**, **108**, **112**, **118**A-**118**D which are inserted into holes (not shown in this figure; shown in FIG. **1**F) in both the left side assembly **150**A and the right side assembly **150**B.

FIG. 1B depicts a fully assembled view of the principal components of the conveyor **100**. The conveyor **100** again comprises the roller assembly **102**. The roller assembly **102** again comprises the leading roller **104**, which again is positioned near the front side **106** of the conveyor **100**.

The roller assembly **102** again further comprises the secondary roller **108**, which is again positioned adjacent to and immediately behind the leading roller **104**. The secondary roller **108** again is coupled to the leading roller **104** by the O-ring belt **110**.

The roller assembly **102** again further comprises the motorized roller **112**, which again is positioned adjacent to and immediately behind the secondary roller **108**. The motorized roller **112** again comprises the motor **114**. The motorized roller **112** again is coupled to the secondary roller **108** by the first poly-V belt **106**A.

The roller assembly **102** again further comprises the plurality of auxiliary rollers **118**A, **118**B, **118**C, **118**D, which again are positioned adjacent to and immediately behind the motorized roller **112**. The motorized roller **112** is again coupled, either directly or indirectly, to the one or more auxiliary rollers **118**A-**118**D. For example, and as depicted, the secondary roller **112** again is physically coupled to the first auxiliary roller **118**A. For example, and as depicted, the secondary roller **108** again is physically coupled to the leading roller **104** by an O-ring belt **110**.

The leading roller **104** again has the leading roller length **122**. The secondary roller **108** again has the secondary roller length **124**. The motorized roller **112** again has the motorized roller length **126**. The auxiliary rollers **118**A-**118**D again have the respective auxiliary roller lengths **130**A-**130**D. The leading roller length **122** again is less than the motorized roller length **126**. The leading roller length **122** again is less than one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D. As depicted, the leading roller length **122** is less than the secondary roller length **124**, the leading roller length **122** is less than the motorized roller length **126**, and the leading roller length **122** is less than each of the respective auxiliary roller lengths **130**A-**130**D.

The leading roller **104** again comprises the first leading O-ring groove **132**A, the first leading O-ring groove **132**A again configured to accommodate an O-ring belt (this O-ring belt is not shown in this figure). The leading roller **104** again comprises the second leading O-ring groove **132**B, the second leading O-ring groove **132**B again configured to accommodate an O-ring belt **110**. The second leading O-ring groove **132**B is again further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**.

The robotic payload conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B.

The left side assembly **150**A and the right side assembly **150**B again hold in place each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D while allowing each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D to rotate. The left side assembly **150**A again comprises the left side assembly bulb **151**A and the right side assembly **150**B again comprises the right side assembly bulb **151**B, the left side assembly bulb **151**A and the right side assembly bulb **151**B together again configured to hold the leading roller **104** in place so that the leading roller length **122** is less than one or more of one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D.

Each of the respective hexagonal shafts **119**A-**119**G is held in place by one or more of the left side assembly **150**A and the right side assembly **150**B. (More details are provided in FIG. 1F.) Preferably, but not necessarily, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D rotates about the respective hexagonal shaft **119**A-**119**G. Alternatively, or additionally, one or more of the respective hexagonal shafts **119**A-**119**G is free to rotate while being held in place by the left side assembly **150**A and by the right side assembly **150**B.

The roller assembly **102** again is operably connected to the left side assembly **150**A. The roller assembly again is operably connected to the right side assembly **150**B.

The conveyor **100** again further comprises the base assembly (not shown in this figure). The base assembly (not shown in this figure) again is operably connected to the roller assembly **102**.

The conveyor **100** again further comprises the backstop **170**. The backstop **170** again is operably connected to the left side assembly **150**A and to the right side assembly **150**B.

FIG. 1C depicts a fully assembled detail view of components of the roller assembly **102**. The roller assembly **102** again comprises the plurality of rollers **104**, **108**, **112**, **118**A-**118**D, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D preferably again being configured to rotate. The roller assembly **102** again comprises the leading roller **104** that is configured to rotate, the leading roller **104** again being positioned near the front side **106**.

The roller assembly **102** again further comprises the secondary roller **108** that is configured to rotate, the secondary roller **108** again being positioned adjacent to and immediately behind the leading roller **104**. The secondary roller **108** again is coupled to the leading roller **104** by the O-ring belt **110**.

The roller assembly **102** again further comprises the motorized roller **112** that is configured to rotate, the motorized roller **108** being positioned adjacent to and immediately behind the secondary roller **108**. The motorized roller **112** comprises the motor **112** configured to cause the motorized roller **112** to rotate. The motorized roller **112** is again coupled to the secondary roller **108** by the first poly-V belt **116**A.

The secondary roller **108** again comprises the secondary poly-V hub **117**A. The motorized roller **112** again further comprises the motorized poly-V hub **117**B. The first poly-V belt **116**A again connects the two adjacent rollers, the secondary roller **108** and the motorized roller **112**, via the secondary poly-V hub **117**A comprised in the secondary roller **108** and the motorized poly-V hub **117**B comprised in the motorized roller **112**.

Like all the poly-V hubs **117**A-**117**F, the secondary poly-V hub **117**A and the motorized poly-V hub **117**A are again configured to transmit power between adjacent rollers. In the case of the secondary poly-V hub **117**A and the motorized poly-V hub **117**B, power again is transmitted between the secondary roller **108** and the motorized roller **112**, the secondary roller **108** and the motorized roller **112** again being coupled by the first poly-V belt **116**A.

Each of the auxiliary rollers **118**A-**118**D again comprises the respective poly-V hub **117**C-**117**F. The first auxiliary roller **118**A again comprises the first auxiliary poly-V hub **117**C. The second auxiliary roller **118**B again comprises the second auxiliary poly-V hub **117**D. The third auxiliary roller **118**C again comprises the third auxiliary poly-V hub **117**E. The fourth auxiliary roller **118**D again comprises the fourth auxiliary poly-V hub **117**F.

The leading roller **104** again has the leading roller length **122**. The secondary roller **108** again has the secondary roller length **124**. The motorized roller **112** again has the motorized roller length **126**. The auxiliary rollers **118**A-**118**D again have the respective auxiliary roller lengths **130**A-**130**D. The leading roller length **122** again is less than the motorized roller length **126**. The leading roller length **122** is less than one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D. As depicted, the leading roller length **122** is less than the secondary roller length **124**, the leading roller length **122** is less than the motorized roller length **126**, and the leading roller length **122** is less than each of the respective auxiliary roller lengths **130**A-**130**D.

The small leading roller length **122** is helpful because it allows the robot (not shown in this figure) carrying the conveyor **100** to approach a payload transfer point more closely than it would otherwise be able to do. When executing a transfer of the payload (not shown in this figure) between the conveyor **100** and another device (not shown in this figure), which in practical terms means a transfer of the payload (not shown in this figure) between the leading roller **104** and another device (not shown in this figure), the closer the leading roller **104** is to the other device (not shown in this figure), the smoother and more reliable the transfer will be. This feature is shown in detail in FIG. **4** below.

The leading roller **104** again comprises the first leading O-ring groove **132**A, the first leading O-ring groove **132**A configured to accommodate an O-ring belt (this O-ring belt is not shown in this figure). The leading roller **104** further comprises the second leading O-ring groove **132**B, the second leading O-ring groove **132**B configured to accommodate the O-ring belt **110**. The second leading O-ring groove **132**B is again further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**. The secondary roller **108** again comprises the first secondary O-ring groove **132**C. The secondary roller **108** again comprises the second secondary O-ring groove **132**D, the second secondary O-ring groove **132**B again configured to accommodate the O-ring belt **110**.

The O-ring belt **110** again is attached to the secondary roller **108** using the second secondary O-ring groove **132**D. The secondary roller **108** again is coupled to the motorized roller **112** using the first poly-V belt **116**A. The secondary roller **108** thereby is configured to receive mechanical power from the motorized roller **112** via the first poly-V belt **116**A. The secondary roller **108** thereby is further configured to transmit mechanical power to the leading roller **104** via the O-ring belt **110**.

The secondary roller **108** again comprises the secondary poly-V hub **117**A. The motorized roller **112** comprises the motorized poly-V hub **117**B. The third poly-V belt **116**C connects the two adjacent rollers, the first auxiliary roller **118**A and the second auxiliary roller **118**B, via the first auxiliary poly-V hub **117**C comprised in the first auxiliary roller **118**A and the second auxiliary poly-V hub **117**D comprised in the second auxiliary roller **118**B.

A parallel description again describes the fourth poly-V belt **116**D, which connects the second auxiliary roller **118**B and the third auxiliary roller **118**C. A parallel description also described the fifth poly-V belt **116**E, which connects the third auxiliary roller **118**C and the fourth auxiliary roller **118**D.

The roller assembly **102** again further comprises the plurality of auxiliary rollers **118**A, **118**B, **118**C, **118**D, each of the auxiliary rollers **118**A-**118**D being configured to rotate, the auxiliary rollers **118**A-**118**D being positioned adjacent to and immediately behind the motorized roller **112**. The motorized roller **112** is again coupled, either directly or indirectly, to the one or more auxiliary rollers **118**A-**118**D. For example, and as depicted, the secondary roller **112** again is physically coupled to the first auxiliary roller **118**A. For example, and as depicted, the secondary roller **108** again is physically coupled to the leading roller **104** by an O-ring belt **110**.

Each of the rollers **104**, **108**, **112**, **118**A-**118**D again further comprises the respective hexagonal shaft **119**A-**119**G on which the respective roller **104**, **108**, **112**, **118**A-**118**D rotates. The leading roller **104** again comprises the leading hexagonal shaft **119**A on which the leading roller **104** rotates. The secondary roller **108** again comprises the secondary hexagonal shaft **119**B on which it rotates. The motorized roller **112** again comprises the motorized hexagonal shaft **119**C on which it rotates. Each of the four auxiliary rollers **118**A-**118**D again comprises the respective first, second, third, or fourth auxiliary hexagonal shaft **119**D-**119**G on which it rotates.

The first auxiliary roller **118**A is again coupled to the second auxiliary roller **118**B by the second poly-V belt **116**B.

The leading roller **104** again has the leading roller length **122**. The secondary roller **108** again has the secondary roller length **124**. The motorized roller **112** again has the motorized roller length **126**. The auxiliary rollers **118**A-**118**D again have the respective auxiliary roller lengths **130**A-**130**D.

FIG. **1**D depicts an exploded view of principal and secondary components of the robotic payload conveyor **100**. The conveyor **100** again comprises the conveyor belt roller assembly **102**. The roller assembly **102** again comprises the plurality of rollers **104**, **108**, **112**, **118**A-**118**D, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D again preferably being configured to rotate. The plurality of rollers **104**, **108**, **112**, **118**A-**118**D again collectively form the roller assembly **102** configured to move the payload (not shown in FIG. **1**D) along the conveyor **100** in the forward direction **120** toward the front side **106** of the conveyor **100**. The roller assembly **102** again comprises the leading roller **104** that is again configured to rotate, the leading roller **104** again being positioned near the front side **106** of the conveyor **100**.

As mentioned above in the discussion of FIG. **1**A, when executing the transfer of the payload (not shown in this figure) between the conveyor **100** and another device (not shown in this figure), which in practical terms means the transfer of the payload (not shown in this figure) between the leading roller **104** and another device (not shown in this figure), the closer the leading roller **104** is to the other device (not shown in this figure), the smoother and more reliable the transfer will be.

The leading roller **104** again comprises the first leading O-ring groove **132**A, the first leading O-ring groove **132**A again configured to accommodate an O-ring belt (this O-ring belt is not shown in this figure). The leading roller **104** again comprises the second leading O-ring groove **132**B, the second leading O-ring groove **132**B again configured to accommodate an O-ring belt **110**. The second leading O-ring groove **132**B is again further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**.

The roller assembly **102** again further comprises the secondary roller **108** that is again configured to rotate, the secondary roller **108** again being positioned adjacent to and immediately behind the leading roller **104**.

The leading roller **104** again comprises the first leading O-ring groove **132**A, the first leading O-ring groove **132**A configured to accommodate an O-ring belt (this O-ring belt is not shown in this figure). The leading roller **104** further comprises the second leading O-ring groove **132**B, the second leading O-ring groove **132**B configured to accommodate the O-ring belt **110**. The second leading O-ring groove **132**B is again further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**. The secondary roller **108** again comprises the first secondary O-ring groove **132**C. The secondary roller **108** again comprises the second secondary O-ring groove **132**D, the second secondary O-ring groove **132**B again configured to accommodate the O-ring belt **110**.

The O-ring belt **110** again is attached to the secondary roller **108** using the second secondary O-ring groove **132**D.

The secondary roller **108** is again coupled to the leading roller **104** by the O-ring belt **110**. The secondary roller **108** is again coupled to the motorized roller **112** by the first poly-V belt **116**A.

The roller assembly **102** again further comprises the motorized roller **112** that is configured to rotate, the motorized roller **108** again being positioned adjacent to and immediately behind the secondary roller **108**. The motorized roller **112** again comprises the motor **114** configured to cause the motorized roller **112** to rotate. The motorized roller **112** again is coupled to the secondary roller **108** by the first poly-V belt **116**A.

The roller assembly **102** again further comprises the plurality of auxiliary rollers **118**A, **118**B, **118**C, **118**D, the auxiliary rollers **118**A-**118**D again being positioned adjacent to and immediately behind the motorized roller **112**. The motorized roller **112** is again coupled, either directly or indirectly, to the one or more auxiliary rollers **118**A-**118**D. For example, and as depicted, the secondary roller **112** again is physically coupled to the first auxiliary roller **118**A. For example, and as depicted, the secondary roller **108** again is physically coupled to the leading roller **104** by an O-ring belt **110**.

Each of the rollers **104**, **108**, **112**, **118**A-**118**D again further comprises the respective hexagonal shaft **119**A-**119**G on which the respective roller **104**, **108**, **112**, **118**A-**118**D rotates. The leading roller **104** again comprises the leading hexagonal shaft **119**A on which the leading roller **104** rotates. The secondary roller **108** again comprises the secondary hexagonal shaft **119**B on which it rotates. The motorized roller **112** again comprises the motorized hexagonal shaft **119**C on which it rotates. Each of the four auxiliary rollers **118**A-**118**D again comprises the respective first, second, third, or fourth auxiliary hexagonal shaft **119**D-**119**G on which it rotates.

The robotic payload conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B. The left side assembly **150**A and the right side assembly **150**B again hold in place each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D while allowing each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D to rotate. The left side assembly **150**A again comprises the left side assembly bulb **151**A and the right side assembly **150**B again comprises the right side assembly bulb **151**B, the left side assembly bulb **151**A and the right side assembly bulb **151**B together again configured to hold the leading roller **104** in place so that the leading roller length **122** is less than one or more of one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D.



Each of the respective hexagonal shafts **119**A-**119**G is held in place by the left side assembly **150**A and by the right side assembly **150**B. (More details are provided in FIG. **1**F.) Preferably, but not necessarily, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D rotates about the respective hexagonal shaft **119**A-**119**G. Alternatively, or additionally, one or more of the respective hexagonal shafts **119**A-**119**G is free to rotate while being held in place by the left side assembly **150**A and by the right side assembly **150**B.

The left side assembly **150**A comprises a left side panel **177**A and a left side housing **178**A. The right side assembly **150**B comprises a right side panel **177**B and a right side housing **178**B. The left side panel **177**A and the right side panel **177**B are configured to hold the poly-V hubs **117**A-**117**F while allowing the poly-V hubs **117**A-**117**F to freely rotate so that the corresponding poly-V belts **116**A-**116**D can rotate. As depicted, the left side housing **178**A is configured to protect one or more of the poly-V hubs **117**A-**117**F and the poly-V belts **116**A-**116**D. As depicted, there are no poly-V hubs **117**A-**117**F on the left side **152**A of the conveyor **100** and there are also no poly-V belts **116**A-**116**D on the left side **152**A of the conveyor **100**. Accordingly, as depicted in this particular example, the right side panel **177**B is configured to hold the poly-V hubs **117**A-**117**F while allowing the poly-V hubs **117**A-**117**F to freely rotate so that the corresponding poly-V belts **116**A-**116**D can rotate.

The secondary roller **108** again comprises the secondary poly-V hub **117**A. The motorized roller **112** again further comprises the motorized poly-V hub **117**B. The first poly-V belt **116**A again connects the two adjacent rollers, the secondary roller **108** and the motorized roller **112**, via the secondary poly-V hub **117**A comprised in the secondary roller **108** and the motorized poly-V hub **117**B comprised in the motorized roller **112**.

Like all the poly-V hubs **117**A-**117**F, the secondary poly-V hub **117**A and the motorized poly-V hub **117**A are again configured to transmit power between adjacent rollers. In the case of the secondary poly-V hub **117**A and the motorized poly-V hub **117**B, power again is transmitted between the secondary roller **108** and the motorized roller **112**, the secondary roller **108** and the motorized roller **112** again being coupled by the first poly-V belt **116**A.

Each of the auxiliary rollers **118**A-**118**D again comprises the respective poly-V hub **117**C-**117**F. The first auxiliary roller **118**A again comprises the first auxiliary poly-V hub **117**C. The second auxiliary roller **118**B again comprises the second auxiliary poly-V hub **117**D. The third auxiliary roller **118**C again comprises the third auxiliary poly-V hub **117**E. The fourth auxiliary roller **118**D again comprises the fourth auxiliary poly-V hub **117**F.

The leading roller **104** again comprises the first leading O-ring groove **132**A, the first leading O-ring groove **132**A configured to accommodate an O-ring belt (this O-ring belt is not shown in this figure). The leading roller **104** further comprises the second leading O-ring groove **132**B, the second leading O-ring groove **132**B configured to accommodate the O-ring belt **110**. The second leading O-ring groove **132**B is again further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**. The secondary roller **108** again comprises the first secondary O-ring groove **132**C. The secondary roller **108** again comprises the second secondary O-ring groove **132**D, the second secondary O-ring groove **132**B again configured to accommodate the O-ring belt **110**.

The O-ring belt **110** again is attached to the secondary roller **108** using the second secondary O-ring groove **132**D. The secondary roller **108** is coupled to the motorized roller

**112** using the first poly-V belt **116**A. The secondary roller **108** thereby is configured to receive mechanical power from the motorized roller **112** via the first poly-V belt **116**A. The secondary roller **108** thereby is further configured to transmit mechanical power to the leading roller **104** via the O-ring belt **110**.

The secondary roller **108** again comprises the secondary poly-V hub **117**A. The motorized roller **112** comprises the motorized poly-V hub **117**B. The third poly-V belt **116**C connects the two adjacent rollers, the first auxiliary roller **118**A and the second auxiliary roller **118**B, via the first auxiliary poly-V hub **117**C comprised in the first auxiliary roller **118**A and the second auxiliary poly-V hub **117**D comprised in the second auxiliary roller **118**B.

A parallel description again describes the fourth poly-V belt **116**D, which connects the second auxiliary roller **118**B and the third auxiliary roller **118**C. A parallel description also described the fifth poly-V belt **116**E, which connects the third auxiliary roller **118**C and the fourth auxiliary roller **118**D.

The right side assembly **150**A further comprises a safety guard **180**. The safety guard **180** is configured to cover the poly-V belts **116**A-**116**D to prevent hazards, for example, a hazard to a human of having a finger pinched. Alternatively, or additionally, the safety guard **180** is configured to discourage a human from inserting one or more of a finger and another body part into a position that is near a point where the poly-V belt **116**A-**116**D meets the roller **108**, **104**, **108**, **112**, **118**A-**118**D.

The left side assembly **150**A further comprises a left roller alignment rail **181**A. The right side assembly **150**B further comprises a right roller alignment rail **181**B. The left and right roller alignment rails **181**A-**181**B are configured to do one or more of cover and protect the roller assembly **102**. More specifically, the left and right roller alignment rails **181**A-**181**B are configured to protect one or more of the safety guard **180**, the poly-V belts **116**A-**116**D, the poly-V hubs **117**A-**117**F, and the rollers **104**, **108**, **112**, **118**A-**118**D.

The conveyor **100** again further comprises the base assembly **160**. The base assembly **160** again serves as a main structural member of the robotic payload conveyor **100**. The base assembly **160** again is operably connected to the left side assembly **150**A and to the right side assembly **150**B. The base assembly **160** again supports the left side assembly **150**A and the right side assembly **150**B. The conveyor **100** again further comprises the backstop **170**. The backstop **170** again is configured to stop motion of the payload (not shown in FIG. **1**D) in the backward direction **172** toward the back side **175** of the conveyor **100**.

FIG. **1**E depicts a further exploded view of principal and secondary components of the robotic payload conveyor **100**. The conveyor **100** again comprises the conveyor belt roller assembly **102**. The roller assembly **102** again comprises the plurality of rollers **104**, **108**, **112**, **118**A-**118**D, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D again preferably being configured to rotate. The plurality of rollers **104**, **108**, **112**, **118**A-**118**D again collectively form the roller assembly **102** configured to move the payload (not shown in FIG. **1**D) along the conveyor **100** in the forward direction **120** toward the front side **106** of the conveyor **100**. The roller assembly **102** again comprises the leading roller **104** that is again configured to rotate, the leading roller **104** again being positioned near the front side **106** of the conveyor **100**.

The leading roller **104** again comprises the first leading O-ring groove **132**A. The leading roller **104** again comprises the second leading O-ring groove **132**B, the second leading O-ring groove **132**B again configured to accommodate the O-ring belt **110**. The second leading O-ring groove **132**B is again further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**.

The roller assembly **102** again further comprises the secondary roller **108** that is again configured to rotate.

The leading roller **104** again comprises the first leading O-ring groove **132**A, the first leading O-ring groove **132**A configured to accommodate an O-ring belt (this O-ring belt is not shown in this figure). The leading roller **104** further comprises the second leading O-ring groove **132**B, the second leading O-ring groove **132**B configured to accommodate the O-ring belt **110**. The second leading O-ring groove **132**B is again further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**. The secondary roller **108** again comprises the first secondary O-ring groove **132**C. The secondary roller **108** again comprises the second secondary O-ring groove **132**D, the second secondary O-ring groove **132**B again configured to accommodate the O-ring belt **110**.

The O-ring belt **110** is again attached to the secondary roller **108** using the second secondary O-ring groove **132**D.

The secondary roller **108** is again coupled to the leading roller **104** by the O-ring belt **110**. The secondary roller **108** is again coupled to the motorized roller **112** by the first poly-V belt **116**A.

The roller assembly **102** again further comprises the motorized roller **112** that is configured to rotate, the motorized roller **108** again being positioned adjacent to and immediately behind the secondary roller **108**. The motorized roller **112** again comprises the motor **114** configured to cause the motorized roller **112** to rotate. The motorized roller **112** again is coupled to the secondary roller **108** by the first poly-V belt **116**A.

The roller assembly **102** again further comprises the plurality of auxiliary rollers **118**A, **118**B, **118**C, **118**D, the auxiliary rollers **118**A-**118**D again being positioned adjacent to and immediately behind the motorized roller **112**. The motorized roller **112** is again coupled, either directly or indirectly, to the one or more auxiliary rollers **118**A-**118**D. For example, and as depicted, the secondary roller **112** again is physically coupled to the first auxiliary roller **118**A. For example, and as depicted, the secondary roller **108** again is physically coupled to the leading roller **104** by an O-ring belt **110**.

Each of the rollers **104**, **108**, **112**, **118**A-**118**D again further comprises the respective hexagonal shaft **119**A-**119**G on which the respective roller **104**, **108**, **112**, **118**A-**118**D rotates. The leading roller **104** again comprises the leading hexagonal shaft **119**A on which the leading roller **104** rotates. The secondary roller **108** again comprises the secondary hexagonal shaft **119**B on which it rotates. The motorized roller **112** again comprises the motorized hexagonal shaft **119**C on which it rotates. Each of the four auxiliary rollers **118**A-**118**D again comprises the respective first, second, third, or fourth auxiliary hexagonal shaft **119**D-**119**G on which it rotates.

The robotic payload conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B. The left side assembly **150**A and the right side assembly **150**B again hold in place each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D while allowing each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D to rotate. The left side assembly **150**A again comprises the left side assembly bulb **151**A and the right side assembly **150**B again comprises the right side assembly bulb **151**B, the left side assembly bulb **151**A and the right side assembly bulb **151**B together again configured to hold the leading roller **104** in place so that the leading roller length **122** is less than one or more of one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D.

Each of the respective hexagonal shafts **119**A-**119**G is held in place by the left side assembly **150**A and by the right side assembly **150**B. (More details are provided in FIG. **1**F.) Preferably, but not necessarily, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D rotates about the respective hexagonal shaft **119**A-**119**G. Alternatively, or additionally, one or more of the respective hexagonal shafts **119**A-**119**G is free to rotate while being held in place by the left side assembly **150**A and by the right side assembly **150**B.

The left side assembly **150**A again comprises the left side panel **177**A and the left side housing **178**A. The right side assembly **150**B again comprises the right side panel **177**B and the right side housing **178**B. The left side panel **177**A and the right side panel **177**B again are configured to hold the poly-V hubs **117**A-**117**F while allowing the poly-V hubs **117**A-**117**F to freely rotate so that the corresponding poly-V belts **116**A-**116**D can rotate.

The right side assembly **150**A again further comprises the safety guard **180**.

The left side assembly **150**A again further comprises the left roller alignment rail **181**A. The right side assembly **150**B again further comprises the right roller alignment rail **181**B.

The conveyor **100** again further comprises the base assembly **160**. The base assembly **160** again serves as a main structural member of the robotic payload conveyor **100**. The base assembly **160** again is operably connected to the left side assembly **150**A and to the right side assembly **150**B. The base assembly **160** again supports the left side assembly **150**A and the right side assembly **150**B.

The conveyor **100** again further comprises the backstop **170**. The backstop **170** again is operably connected to the left side assembly **150**A and to the right side assembly **150**B. The backstop **170** again is configured to stop motion of the payload (not shown in FIG. **1**E) in the backward direction **172** toward the back side **175** of the conveyor **100**. Alternatively, or additionally, the roller assembly **102** is configured to move the payload (not shown in FIG. **1**E) along the conveyor **100** in a backward direction.

FIG. **1**F depicts a further exploded view of principal and secondary components of the robotic payload conveyor **100**. The conveyor **100** again comprises the conveyor belt roller assembly **102**. The roller assembly **102** again comprises the plurality of rollers **104**, **108**, **112**, **118**A-**118**D, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D again preferably being configured to rotate. The plurality of rollers **104**, **108**, **112**, **118**A-**118**D again collectively form the roller assembly **102** configured to move the payload (not shown in FIG. **1**D) along the conveyor **100** in the forward direction **120** toward the front side **106** of the conveyor **100**. The roller assembly **102** again comprises the leading roller **104** that is again configured to rotate, the leading roller **104** again being positioned near the front side **106** of the conveyor **100**.

The leading roller **104** again comprises the first leading O-ring groove **132**A. The leading roller **104** again comprises the second leading O-ring groove **132**B, the second leading O-ring groove **132**B again configured to accommodate an O-ring belt **110**. The second leading O-ring groove **132**B is again further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**.

The roller assembly **102** again further comprises the secondary roller **108** that is again configured to rotate.

The leading roller **104** again comprises the first leading O-ring groove **132**A, the first leading O-ring groove **132**A configured to accommodate an O-ring belt (this O-ring belt is not shown in this figure). The leading roller **104** further comprises the second leading O-ring groove **132**B, the second leading O-ring groove **132**B configured to accommodate the O-ring belt **110**. The second leading O-ring groove **132**B is again further configured to prevent the O-ring belt **110** from moving from side to side on the leading roller **104**. The secondary roller **108** again comprises the first secondary O-ring groove **132**C. The secondary roller **108** again comprises the second secondary O-ring groove **132**D, the second secondary O-ring groove **132**B again configured to accommodate the O-ring belt **110**.

The O-ring belt **110** is again attached to the secondary roller **108** using the second secondary O-ring groove **132**D.

The secondary roller **108** is again coupled to the leading roller **104** by the O-ring belt **110**. The secondary roller **108** is again coupled to the motorized roller **112** by the first poly-V belt **116**A.

The roller assembly **102** again further comprises the motorized roller **112** that is configured to rotate, the motorized roller **108** again being positioned adjacent to and immediately behind the secondary roller **108**. The motorized roller **112** again comprises the motor **114** configured to cause the motorized roller **112** to rotate. The motorized roller **112** again is coupled to the secondary roller **108** by the first poly-V belt **116**A.

The roller assembly **102** again further comprises the plurality of auxiliary rollers **118**A, **118**B, **118**C, **118**D, the auxiliary rollers **118**A-**118**D again being positioned adjacent to and immediately behind the motorized roller **112**. The motorized roller **112** is again coupled, either directly or indirectly, to the one or more auxiliary rollers **118**A-**118**D. For example, and as depicted, the secondary roller **112** again is physically coupled to the first auxiliary roller **118**A. For example, and as depicted, the secondary roller **108** again is physically coupled to the leading roller **104** by an O-ring belt **110**.

Each of the rollers **104**, **108**, **112**, **118**A-**118**D again further comprises the respective hexagonal shaft **119**A-**119**G on which the respective roller **104**, **108**, **112**, **118**A-**118**D rotates. The leading roller **104** again comprises the leading hexagonal shaft **119**A on which the leading roller **104** rotates. The secondary roller **108** again comprises the secondary hexagonal shaft **119**B on which it rotates. The motorized roller **112** again comprises the motorized hexagonal shaft **119**C on which it rotates. Each of the four auxiliary rollers **118**A-**118**D again comprises the respective first, second, third, or fourth auxiliary hexagonal shaft **119**D-**119**G on which it rotates.

The robotic payload conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B. The left side assembly **150**A again comprises the left side assembly bulb **151**A and the right side assembly **150**B again comprises the right side assembly bulb **151**B, the left side assembly bulb **151**A and the right side assembly bulb **151**B together again configured to hold the leading roller **104** in place so that the leading roller length **122** is less than one or more of one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D.

The left side assembly **150**A and the right side assembly **150**B hold the hexagonal shafts **119**A-**119**G while allowing the rollers to each turn on its respective hexagonal shaft **119**A-**119**G. The left side assembly **150**A again comprises the left side panel **177**A and the left side housing **178**A. The left side panel **177**A and the left side housing **178**A are attached together using left side assembly fasteners **192**A-**192**D to form the left side assembly **150**A. For example, the left side assembly fasteners **192**A-**192**D comprise screws.

The right side assembly **150**B again comprises the right side panel **177**B and the right side housing **178**B. The right side panel **177**B and the right side housing **178**B are attached together using right side assembly fasteners **193**A-**193**D to form the right side assembly **150**A. For example, the right side assembly fasteners **193**A-**193**D comprise screws.

The left side panel **177**A and the right side panel **177**B again are configured to hold the poly-V hubs **117**A-**117**F while allowing the poly-V hubs **117**A-**117**F to freely rotate so that the corresponding poly-V belts **116**A-**116**D can rotate. The left side panel **177**A further comprises left side shaft holes **189**A-**189**G. The right side panel **177**B further comprises right side shaft holes **190**A-**190**G.

The right side assembly **150**A again further comprises the right safety guard **180**.

The left side assembly **150**A again further comprises the left roller alignment rail **181**A. The right side assembly **150**B again further comprises the right roller alignment rail **181**B.

Each of the rollers **104**, **108**, **112**, **118**A-**118**D again comprises the respective hexagonal shaft **119**A-**119**G on which the roller **104**, **108**, **112**, **118**A-**118**D rotates. Each of the respective hexagonal shafts **119**A-**119**G is again held in place by the left side assembly **150**A and by the right side assembly **150**B via the respective left side shaft hole **189**A-**189**G and the respective right side shaft hole **190**A-**190**G. Preferably, but not necessarily, each of the plurality of rollers **104**, **108**, **112**, **118**A-**118**D rotates about the respective hexagonal shaft **119**A-**119**G. Alternatively, or additionally, one or more of the respective hexagonal shafts **119**A-**119**G is free to rotate while being held in place by the left side assembly **150**A and by the right side assembly **150**B.

For example, the leading hexagonal shaft **119**A is held in place by the left side assembly **150**A and by the right side assembly **150**B via a first left side shaft hole **189**A and a first right side shaft hole **190**A. Relative to the left side shaft holes **189**B-**189**G for the six other rollers **108**, **104**, **108**, **112**, **118**A-**118**D, the left side shaft hole **189**A is located in a position on the left side panel **177**A that is closer to the right side panel **177**B. Relative to the right side shaft holes **190**B-**189**G for the six other rollers **108**, **104**, **108**, **112**, **118**A-**118**D, the right side shaft hole **190**A is located in a position on the right side panel **177**B that is closer to the left side panel **177**A. This means, as mentioned above, that the leading roller length **122** is less than the secondary roller length **124**, the leading roller length **122** is less than the motorized roller length **126**, and the leading roller length **122** is less than each of the respective auxiliary roller lengths **130**A-**130**D.

For example, the secondary hexagonal shaft **119**B is held in place by the left side assembly **150**A and by the right side assembly **150**B via a second left side shaft hole **189**B and a second right side shaft hole **190**B. A similar description applies to the motorized hexagonal shaft **119**C and to the first, second, third, and fourth auxiliary hexagonal shafts **119**D-**119**G.

The conveyor **100** again further comprises the base assembly **160**. The base assembly **160** again supports the left side assembly **150**A and the right side assembly **150**B.

The right side assembly **150**B is fastened to the base assembly **160** using a plurality of right side assembly-base assembly fasteners **194**A-**194**E. For example, the right side assembly-base assembly fasteners **194**A-**194**E fasteners comprise screws. The left side assembly **150**A is similarly fastened to the base assembly **160** using a plurality of left side assembly-base assembly fasteners (not shown in this figure).

The conveyor **100** again further comprises the backstop **170**. The backstop **170** again is configured to stop motion of the payload (not shown in FIG. **1**F) in the backward direction **172** toward the back side **175** of the conveyor **100**. The backstop **170** is fastened to the base assembly **160** using backstop-base fasteners **195**A-**195**C. For example, the backstop-base fasteners **195**A-**195**C comprise screws. The backstop **170** is fastened to the left side assembly **150**A using backstop-left side assembly fasteners **196**A-**196**C. For example, the backstop-left side assembly fasteners **196**A-**196**C comprise screws. The backstop **170** is fastened to the right side assembly **150**B using backstop-right side assembly fasteners **197**A-**197**C. For example, the backstop-right side assembly fasteners **197**A-**197**C comprise screws.

The right roller alignment rail **181**B is attached to the safety guard **180** using right safety fasteners **199**A-**199**B. For example, the right safety fasteners **199**A-**199**B comprise screws.

FIGS. **2**A-**2**D are a set of four drawings of the robotic payload transport system.

FIG. **2**A depicts an exploded drawing of principal components of the robotic payload transport system **200**. The robotic payload transport system **200** comprises the robotic payload conveyor **100**. The conveyor **100** again comprises the roller assembly **102**. The roller assembly **102** again comprises the rollers **104**, **108**, **112**, **118**A-**118**D. The conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B. The left side assembly **150**A again comprises the left side assembly bulb **151**A and the right side assembly **150**B again comprises the right side assembly bulb **151**B.

The robotic payload transport system **200** further comprises a riser assembly **210** operably attached to the conveyor **100**, the riser assembly configured to support the roller conveyor **100**. The system **200** further comprises the mobile robot **220**. The riser assembly **210** comprises a structure that allows adjustment of a height **230** of the conveyor **100**, thereby allowing for different heights **230** of the roller assembly **102** above the robot **220**. (The roller assembly height **230** is essentially the same as the conveyor height **230**.) The riser assembly **210** can be designed for a fixed height **230** of interest. Alternatively, or additionally, the riser assembly **210** permits one or more of manual adjustment of the height **230** and automatic adjustment of the height **230**. For example, the mobile robot **220** comprises a robot **220** that has the ability to move around in a building (not shown in the figure). For example, the mobile robot **220** comprises a robot **220** that has the ability to move around in a building (not shown in the figure) while carrying a payload (not shown in the figure). For example, the building comprises a warehouse.

For example, the mobile robot **220** comprises a Freight **100** mobile robot manufactured by Fetch Robotics of San Jose, Calif. (www.fetchrobotics.com).

FIG. **2**B depicts a fully assembled view of the principal components of the robotic payload transport system **200**. The robotic payload transport system **200** again comprises the conveyor **100**. The conveyor **100** again comprises the roller assembly **102**. The roller assembly **102** again comprises the rollers **104**, **108**, **112**, **118**A-**118**D. The conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B. The robotic payload conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B. The left side assembly **150**A again comprises the left side assembly bulb **151**A and the right side assembly **150**B again comprises the right side assembly bulb **151**B, the left side assembly bulb **151**A and the right side assembly bulb **151**B together again configured to hold the leading roller **104** in place so that the leading roller length **122** is less than one or more of one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D.

FIG. **2**B also shows the forward direction **120** toward the front side **106** of the conveyor **100** and the backward direction **175** toward the back side **175** of the conveyor **100**. The robotic payload transport system **200** again further comprises the riser assembly **210**, which is again operably attached to the conveyor **100**. The riser assembly **210** again comprises an actuator (not shown in this figure; shown in FIGS. **2**D-**2**E) that allows adjustment of the height **230** of the conveyor **100**, thereby allowing for different heights **230** of the rollers **104**, **108**, **112**, **118**A-**118**D. The riser assembly **210** can again be designed for the fixed height **230** of interest. Alternatively, or additionally, the riser assembly **210** again permits one or more of manual adjustment of the height **230** and automatic adjustment of the height **230**. As shown in FIG. **2**B, the riser assembly **210** is adjusted for a minimum height **230**A of the conveyor **100** above the mobile robot **220**.

FIG. **2**C depicts a fully assembled view of the principal components of the robotic payload transport system **200**. The robotic payload transport system **200** again comprises the conveyor **100**. The conveyor **100** again comprises the roller assembly **102**. The roller assembly **102** again comprises the rollers **104**, **108**, **112**, **118**A-**118**D. The robotic payload transport system **200** again further comprises the riser assembly **210**, which is again operably attached to the conveyor **100**. The riser assembly **210** again comprises an actuator (not shown in this figure; shown in FIGS. **2**D-**2**E) that allows adjustment of the height **230** of the conveyor **100**, thereby allowing for different heights **230** of the rollers **104**, **108**, **112**, **118**A-**118**D. The conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B. The robotic payload conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B. The left side assembly **150**A again comprises the left side assembly bulb **151**A and the right side assembly **150**B again comprises the right side assembly bulb **151**B, the left side assembly bulb **151**A and the right side assembly bulb **151**B together again configured to hold the leading roller **104** in place so that the leading roller length **122** is less than one or more of one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D.

FIG. **2**C also again shows the forward direction **120** toward the front side **106** of the conveyor **100** and the backward direction **178** toward the back side **175** of the conveyor **100**. The riser assembly **210** can again be designed for the fixed height **230** of interest. Alternatively, or additionally, the riser assembly **210** again permits one or more of manual adjustment of the height **230** and automatic adjustment of the height **230**. As shown in FIG. **2**C, the riser assembly **210** is adjusted for a maximum height **230**B of the conveyor **100** above the mobile robot **220**.

FIGS. **2**D-**2**E depict two fully assembled side views of the principal components of the robotic payload transport system **200**. FIG. **2**D depicts a side view of the robotic payload transport system **200** seen in FIG. **2**B, again comprises the conveyor **100**, the riser assembly **210**, and the robot **220**. The riser assembly **210** comprises an actuator **225**.

The actuator **225** is used to adjust the height **230** of the conveyor **100** above the mobile robot **220**. The riser assembly **210** can again be designed for the fixed height **230** of interest. Alternatively, or additionally, the riser assembly **210** again permits one or more of manual adjustment of the height **230** using the actuator **225** and automatic adjustment of the height **230** using the actuator **225**. As in FIG. **2**B, the riser assembly **210** is adjusted for a minimum height **230**A of the conveyor **100** above the mobile robot **220**.

FIG. **2**E depicts a side view of the robotic payload transport system **200** seen in FIG. **2**C. The system **200** again comprises the conveyor **100**, the riser assembly **210**, and the robot **220**. The riser assembly **210** again comprises the actuator **225**.

The actuator **225** is again used to adjust the height **230** of the conveyor **100** above the mobile robot **220**. The riser assembly **210** can again be designed for the fixed height **230** of interest. Alternatively, or additionally, the riser assembly **210** again permits one or more of manual adjustment of the height **230** using the actuator **225** and automatic adjustment of the height **230** using the actuator **225**. As in FIG. **2**C, the riser assembly **210** is adjusted for a maximum height **230**B of the conveyor **100** above the mobile robot **220**.

FIG. **3** depicts a fully assembled view of the principal components of the robotic payload transport system **200** while in use to transport a payload **310**. As depicted, the payload **310** comprises a bin **310**. The system **200** again comprises the roller conveyor **100**, the riser assembly **210**, and the mobile robot **220**. The conveyor **100** again comprises the leading roller **104** (the other rollers are not shown in this figure). The robotic payload transport system **200** again comprises the robotic payload conveyor **100**, the riser assembly **210**, and the mobile robot **220**.

FIG. **4** is a top view drawing of the roller conveyor **100** mounted to the mobile robot **220**, which has the substantially circular profile **220**. The conveyor **100** again comprises the roller assembly **102**. The roller assembly **102** again comprises the leading roller **104**, the secondary roller **108**, the motorized roller **112**, and the auxiliary rollers **118**A-**118**D. The motorized roller **112** again comprises the motor **114**. The conveyor **100** again further comprises the left side assembly **150**A and the right side assembly **150**B. The conveyor **100** again further comprises the backstop **170**. Also shown are the front side **106** and the back side **175** of the conveyor **100**. The conveyor **100** again further comprises the safety guard **180**, the left roller alignment rail **181**A and the right roller alignment rail **181**B.

The leading roller **104** again has the leading roller length **122**. The secondary roller **108** again has the secondary roller length **124**. The motorized roller **112** again has the motorized roller length **126**. The auxiliary rollers **118**A-**118**D again have the respective auxiliary roller lengths **130**A-**130**D. The leading roller length **122** again is less than the motorized roller length **126**. The leading roller length **122** is less than one or more of the secondary roller length **124**, the motorized roller length **126**, and the respective auxiliary roller lengths **130**A-**130**D. As depicted, the leading roller length **122** is less than the secondary roller length **124**, the leading roller length **122** is less than the motorized roller length **126**, and the leading roller length **122** is less than each of the respective auxiliary roller lengths **130**A-**130**D.

The circle **220** circumscribes a circular profile **220** of a smallest diameter within which the roller conveyor **100** can be enclosed. A leading roller offset **410** equals a distance from the leading roller **104** to a nearest leading point **420** comprised in the circular profile **220**.

The relatively small leading roller length **122** facilitates a small value for the leading roller offset **410**, because the leading roller **104** is able to come closer to an edge of the circle **220** than would be the case if the leading roller length **122** were closer to the length of the other rollers **108**, **112**, **118**A-**118**D.

The leading roller offset **410** is lowered due to the leading roller length **122** being less than the length of at least one of the other rollers. Furthermore, the leading roller offset **410** is lowered due to the leading roller length **122** being less than the secondary roller length **124**, the leading roller length **122** being less than the motorized roller length **126**, and the leading roller length **122** being less than each of the respective auxiliary roller lengths **130**A-**130**D.

The roller conveyor system is configured to provide one or more of high power transmission and a compact profile, wherein high power transmission is defined as transmission of between approximately 50 watts and approximately 100 watts for a payload of approximately 150 pounds, and wherein high power transmission is further defined as transmission of approximately 500 watts for a payload of approximately 2,000 pounds.

Alternatively, or additionally, the roller conveyor system is configured to provide both high power transmission and a compact profile, wherein high power transmission is defined as transmission of between approximately 50 watts and approximately 100 watts for a payload of approximately 150 pounds, and wherein high power transmission is further defined as transmission of approximately 500 watts for a payload of approximately 2,000 pounds.

FIG. **5** is a top view drawing of a system **500** comprising the roller conveyor **100** mounted on the mobile robot **220** in use in conjunction with a stationary conveyor **510**. As mentioned above in connection with FIGS. **1**A and **1**D (the point is also applicable to FIGS. **1**E and **1**F), when executing a transfer of the payload **310** between the conveyor **100** and another device such as the stationary conveyor **510**, which in practical terms means a transfer of the payload (not shown in this figure) from the leading roller **104** to another device (not shown in this figure), the closer the leading roller **104** is to the other device (not shown in this figure), the smoother and more reliable the transfer will be. The roller conveyor **100** again comprises the leading roller **104**.

The stationary conveyor **510** comprises a plurality of stationary conveyor rollers **520**A-**520**S including a leading stationary conveyor roller **510**A, a secondary stationary roller **510**B, and a terminating stationary roller **510**S. The stationary conveyor **510** further comprises the payload **310**, the payload **310** again comprising the bin **310**. The bin **310** comprises items **520**A-**520**E. For example, items **520**A-**520**E comprises order items **520**A-**520**E that the mobile robot **220** will be delivering in preparation for shipping to a customer. For example, items **520**A-**520**E comprise inventory items **520**A-**520**E that have been received and which the mobile robot **220** will be delivering to inventory storage. The stationary conveyor **510** further comprises a left stationary conveyor side guide **560**A and a right stationary conveyor side guide **560**B. The left and right stationary conveyor side guides **560**A and **560**B are usable to center the bin **310** on the conveyor **100** so that the bin **310** consistently comes out of the stationary conveyor **510** at a same departure position **570** each time the bin **310** leaves the stationary conveyor **510** and regardless of an entry position (not shown) of the bin **310** when the bin **310** enters the stationary conveyor **510**. The left and right stationary conveyor side guides **560**A and **560**B are important in applications in which the departure position **570** of the bin **310** is critical, for example, when the stationary conveyor **510** is wider than the roller conveyor **100**.

The mobile robot **220** comprising the roller conveyor **100** positions itself immediately adjacent to the stationary conveyor **510**. For example, the mobile robot **220** comprising the roller conveyor **100** positions itself at a distance from the stationary conveyor **510** equal to the leading roller offset **410** discussed in FIG. **4**. For example, one typical workflow entails the roller conveyor **100** loading the bin **310** onto the stationary roller conveyor **510**. The leading roller offset **410** comprises a minimum distance that the mobile robot **220** comprising the roller conveyor **100** can have can from the stationary conveyor **510**.

For example, after unloading the bin **310**, it may be desirable that the mobile robot **220** perform a zero point turn and rotate 180 degrees to continue in an outward direction **540** away from the stationary conveyor **510** in order for the mobile robot **220** comprising the roller conveyor **100** to proceed to a next location to perform a next step in its workflow. The mobile robot **220** simply backing up in the outward direction **540** may be less desirable due, for example, to one or more of a lack of backward-facing sensors on the mobile robot **220** and a physical inability of the mobile robot **220** to directly switch directions by 180 degrees without turning. Alternatively, or additionally, the mobile robot **220** comprising the roller conveyor **100** may rotate 90 degrees clockwise and then proceed in a first perpendicular direction **550**A. Alternatively, or additionally, the mobile robot **220** comprising the roller conveyor **100** may rotate 90 degrees counter-clockwise and then proceed in a second perpendicular direction **550**B.

Advantages of embodiments of the invention include a design allowing for one or more of a compact profile and high power transmission. Further advantages of embodiments of the invention include a design allowing for both a compact profile and high power transmission. Advantages of the hybrid design of the power transmission include that it enables a shorter leading roller to be closer to the edge of the circular perimeter profile of the mechanism, without a need for rollers to be coupled with a Poly-V belt, and without a requirement that the leading and secondary rollers have the same length.

Further advantages of embodiments of the invention include that the compact profile can facilitate the mobile robot performing a zero point turn and rotating 180 degrees to continue in an outward direction away from a stationary conveyor or other delivery/pickup point. A still additional advantage is that thereby the utility of a robot lacking backward sensors is enhanced. Yet further advantages of embodiments of the invention include that the mobile robot can come to a distance from the stationary conveyor or other delivery/pickup point that is equal to the leading roller offset and less than the prior art. A still additional advantage is that the leading roller offset is also less than would be the case if the leading roller length were closer to the lengths of the other rollers.

A further advantage of embodiments of the invention is that, for a given payload width and a given payload length, embodiments of the invention allow the roller conveyor to fit within a smaller circular profile, thereby permitting superior autonomous navigation for the mobile robot. That is, the hybrid belt drive supports a larger volume payload in a given circular profile than a standard belt transmission. Additionally, according to embodiments of the invention, relative to the prior art, a robot having only forward-looking sensors can perform a 180-degree turn can hold a larger volume payload that fits within a circular profile.

The two different power transmissions allow the rollers to rotate together using the two different power transmission methods, thereby allowing for preferable geometry of the overall system. Alternatively, or additionally, the power transmission uses a single power transmission method.

Further advantages of the invention include the smaller leading roller offset **410** as shown in FIG. **4**. The smaller leading roller offset dimension helps minimize the danger of the bin falling between the roller conveyor and the stationary conveyor during autonomous transfer of the bin between the roller conveyor and the stationary conveyor, thereby minimizing damage to one or more of the bin, the robot, and the conveyor. This smaller dimension also allows for transfer of more bins and/or transfer of smaller bins that may get stuck between the rollers if the gap is larger.

Other representative embodiments can be implemented using one or more of different configurations and different components. For example, details of the assembly of components of the robotic payload transport system could be altered without substantially affecting the functioning of embodiments of the invention. For example, screws could be positioned differently. Screws could attach from the opposite side of the device relative to what is depicted in FIG. **1**F. Other attachment methods not involving screws could be used.

For example, it will be understood by those skilled in the art that software used by the robotic payload conveyor may be located in any location in which it may be accessed by the system. For example, it will be understood by one of ordinary skill in the art that the order of certain fabrication steps and certain components can be altered without substantially impairing the functioning of the invention. It is intended, therefore, that the subject matter in the above description shall be interpreted as illustrative and shall not be interpreted in a limiting sense.

For example, embodiments of the invention could comprise one or more of a different number of primary rollers, a different number of secondary rollers, a different number of motorized rollers, and a different number of auxiliary rollers, including in certain embodiments one or more of zero primary rollers, zero secondary rollers, zero motorized rollers, and zero auxiliary rollers. For example, according to certain alternative embodiments, the motorized roller could be the leading roller. For example, one or more rollers could be a non-rotating roller. For example, at least one of the shafts is non-hexagonal. For example, all the shafts are non-hexagonal. For example, at least one of the rollers rotates on a respective shaft. For example, all the rollers rotate on their respective shafts. For example, other embodiments of the invention could comprise both the roller assembly and a conveyor belt. For example, further embodiments of the invention could comprise the roller assembly with a conveyor belt positioned across the roller assembly. For example, yet further embodiments of the invention could comprise a combination of the roller assembly and the conveyor belt.

Alternatively, or additionally, instead of a design requiring both poly-V belts and O-ring belts, embodiments of the invention can employ only poly-V belts and no O-ring belts. Alternatively, or additionally, instead of a design requiring both poly-V belts and O-ring belts, embodiments of the invention can employ only O-ring belts and no poly-V belts. Alternatively, or additionally, embodiments of the invention can operate without a motorized roller, using all idler rollers, that is, all rollers that are not motorized rollers. According to these sets of embodiments, for example, a separate motor drives the rollers using a set of belts.

Alternatively, or additionally, embodiments of the invention could comprise different configurations of one or more of the poly-V belts and the O-ring belts, including one or more of zero poly-V belts and zero O-ring belts. Alternatively, or additionally, a poly-V belt can connect two rollers that are not adjacent to each other. Alternatively, or additionally, an O-ring belt can connect two rollers that are not adjacent to each other.

Alternative methods of power transmission capable of transmitting power between two rollers and usable by embodiments of the invention include, in addition to one or more of O-ring belts and poly-V belts, roller chains, timing belts, round belts, V-belts, flat belts, line shafts, and gears.

The representative embodiments and disclosed subject matter, which have been described in detail herein, have been presented by way of example and illustration and not by way of limitation. It will be understood by those skilled in the art that various changes may be made in the form and details of the described embodiments resulting in equivalent embodiments that remain within the scope of the invention. It is intended, therefore, that the subject matter in the above description shall be interpreted as illustrative and shall not be interpreted in a limiting sense.

What is claimed is:

**1**. A roller conveyor system configured for installation on top of a mobile robot to provide robotic transport of a payload, comprising:

a roller conveyor, the roller conveyor comprising:

a roller assembly comprising a plurality of rollers, the rollers configured to move a payload, each of the rollers being configured to rotate, the roller assembly comprising a leading roller positioned nearest to a front side of the roller conveyor, the leading roller having a leading roller length, the roller assembly further comprising a motorized roller, the motorized roller comprising a motor configured to cause the motorized roller to rotate, the motorized roller having a motorized roller length; and

a power transmission configured to drive the rollers, the power transmission coupling the motorized roller to the leading roller, wherein the leading roller length is less than the motorized roller length.

**2**. The roller conveyor system of claim **1**, further comprising a riser assembly configured to support the roller conveyor.

**3**. The roller conveyor system of claim **2**, wherein the riser assembly comprises an actuator usable to adjust a height of the roller conveyor above the mobile robot.

**4**. The roller conveyor system of claim **1**, wherein the power transmission comprises a belt drive.

**5**. The roller conveyor system of claim **4**, wherein the belt drive comprises a hybrid belt drive.

**6**. The roller conveyor system of claim **1**, wherein the rollers are configured to move the payload toward a front side of the roller conveyor.

**7**. The roller conveyor system of claim **1**, wherein the rollers are configured to move the payload toward a back side of the roller conveyor.

**8**. The roller conveyor system of claim **1**, the roller assembly further comprising one or more auxiliary rollers, the auxiliary rollers being adjacent to and behind the motorized roller, each of the auxiliary rollers having a respective auxiliary roller length.

9. The roller conveyor system of claim 8, wherein the motorized roller is coupled, either directly or indirectly, to one or more auxiliary rollers.

10. The roller conveyor system of claim 8, wherein the motorized roller is physically coupled to one or more auxiliary rollers.

11. The roller conveyor system of claim 8, wherein the motorized roller is physically coupled to one or more auxiliary rollers by one or more poly-V belts.

12. The roller conveyor system of claim 8, wherein the leading roller length is less than one or more of the auxiliary roller lengths.

13. The roller conveyor system of claim 8, wherein the leading roller length is less than each of the auxiliary roller lengths.

14. The roller conveyor system of claim 1, wherein all rollers rotate in a same direction.

15. The roller conveyor system of claim 8, wherein the roller assembly further comprises a secondary roller positioned adjacent to and immediately behind the leading roller, the secondary roller having a secondary roller length.

16. The roller conveyor system of claim 15, wherein the leading roller length is less than the secondary roller length.

17. The roller conveyor system of claim 15, wherein the leading roller length is less than the motorized roller length.

18. The roller conveyor system of claim 15, wherein the leading roller length is less than the secondary roller length, the leading roller length is less than the motorized roller length, and the leading roller length is less than each of the respective auxiliary roller lengths.

19. The roller conveyor system of claim 15, wherein the motorized roller is positioned adjacent to and immediately behind the secondary roller.

20. The roller conveyor system of claim 19, wherein the motorized roller is coupled, either directly or indirectly, to the secondary roller.

21. The roller conveyor system of claim 19, wherein the motorized roller is physically coupled to the secondary roller.

22. The roller conveyor system of claim 19, wherein the motorized roller is physically coupled to the secondary roller by a poly-V belt.

23. The roller conveyor system of claim 15, wherein the secondary roller is coupled, either directly or indirectly, to the leading roller.

24. The roller conveyor system of claim 15, wherein the secondary roller is physically coupled to the leading roller.

25. The roller conveyor system of claim 15, wherein the secondary roller is physically coupled to the leading roller by an O-ring belt.

26. The roller conveyor system of claim 19, wherein the roller assembly further comprises exactly four auxiliary rollers.

27. The roller conveyor system of claim 26, wherein the roller assembly further comprises exactly five poly-V belts, the five poly-V belts collectively coupling the four auxiliary rollers, the motorized roller, and the secondary roller.

28. The roller conveyor system of claim 27, wherein the roller assembly further comprises exactly one O-ring belt coupling the secondary roller and the primary roller.

29. The roller conveyor system of claim 1, wherein the roller conveyor further comprises a backstop operably connected to the roller assembly at a back side of the conveyor.

30. The roller conveyor system of claim 29, wherein the backstop is configured to stop motion of the payload toward the back side of the conveyor.

31. The roller conveyor of claim 30, wherein the leading roller offset represents an approximate minimum distance between the mobile robot comprising the roller conveyor and a stationary conveyor at which the mobile robot is performing one or more of a payload dropoff and a payload pickup.

32. The roller conveyor system of claim 30, wherein the leading roller offset is lowered due to the leading roller length being less than the length of at least one of the other rollers.

33. The roller conveyor system of claim 30, wherein the leading roller offset is lowered due to the leading roller length being less than the secondary roller length, the leading roller length being less than the motorized roller length, and the leading roller length being less than each of the respective auxiliary roller lengths.

34. The roller conveyor system of claim 30, wherein the roller conveyor system is configured to provide one or more of high power transmission and a compact profile.

35. The roller conveyor system of claim 34, wherein high power transmission is defined as transmission of between approximately 50 watts and approximately 100 watts for a payload of approximately 150 pounds, and wherein high power transmission is further defined as transmission of approximately 500 watts for a payload of approximately 2,000 pounds.

36. The roller conveyor system of claim 30, wherein the roller conveyor system is configured to provide both high power transmission and a compact profile.

37. The roller conveyor system of claim 36, wherein high power transmission is defined as transmission of between approximately 50 watts and approximately 100 watts for a payload of approximately 150 pounds, and wherein high power transmission is further defined as transmission of approximately 500 watts for a payload of approximately 2,000 pounds.

38. A roller conveyor system configured for installation on top of a mobile robot to provide robotic transport of a payload, comprising:

a roller conveyor, the roller conveyor comprising:

a roller assembly comprising a plurality of rollers rotating in a same direction, the rollers configured to move a payload toward a front side of the roller conveyor, each of the rollers being configured to rotate, the roller assembly comprising a leading roller positioned nearest to a front side of the roller conveyor, the leading roller having a leading roller length, the roller assembly further comprising a motorized roller, the motorized roller comprising a motor configured to cause the motorized roller to rotate, the motorized roller having a motorized roller length, the roller assembly further comprising one or more auxiliary rollers, the auxiliary rollers being adjacent to and behind the motorized roller, each of the auxiliary rollers having a respective auxiliary roller length, the motorized roller being physically coupled to the one or more auxiliary rollers by one or more poly-V belts, the roller assembly further comprising a secondary roller physically coupled to the motorized roller by a poly-V belt, the secondary roller also physically coupled to the leading roller by an O-ring belt, the secondary roller positioned adjacent to and immediately behind the leading roller, the secondary roller having a secondary roller length, wherein the motorized roller is positioned adjacent to and immediately behind the secondary roller, wherein the leading roller length is less than the secondary roller length, the leading roller length is less than the motorized roller length, and the leading roller length is less than each of the respective auxiliary roller lengths;

a backstop operably connected to the roller assembly at a back side of the conveyor, the backstop configured to stop motion of the payload toward the back side of the conveyor; and

a hybrid belt drive configured to drive the rollers, the drive coupling the motorized roller to the leading roller; and

a riser assembly configured to support the roller conveyor, the riser assembly comprising an actuator usable to adjust a height of the roller conveyor above the mobile robot.

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